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PRESENTED BY

Mrs. Wm. S. Cleveland

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Fig. 1.

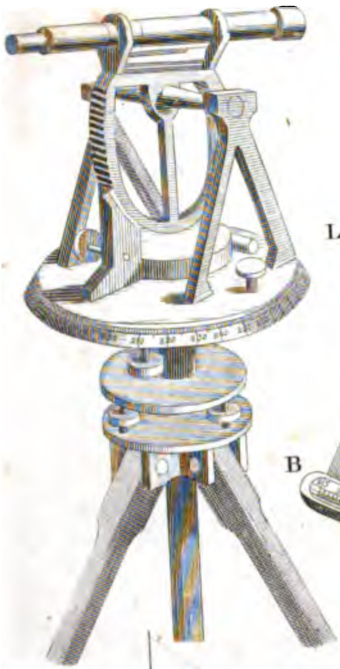


Fig. 2. *Fig. 3.*

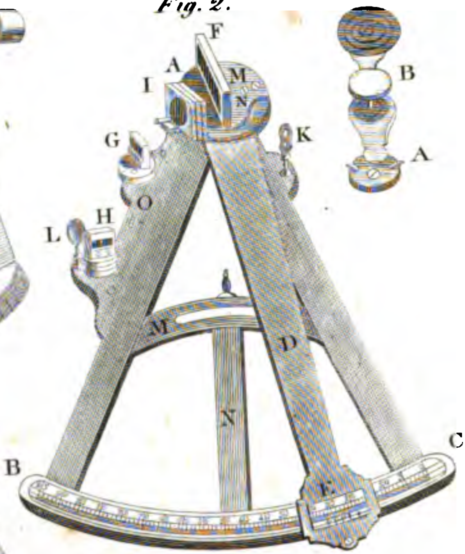
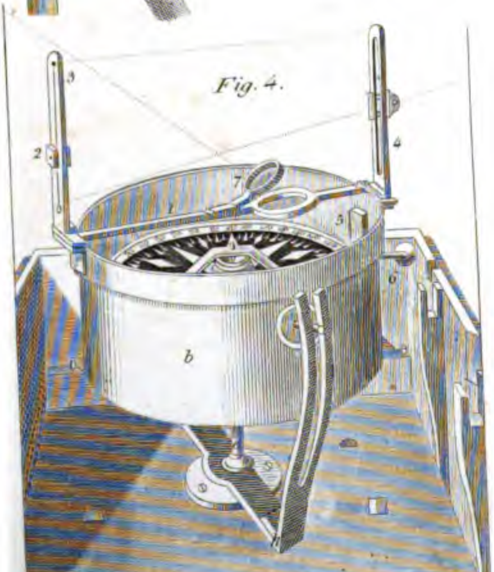


Fig. 4.



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THE

THEORY AND PRACTICE

OF

SURVEYING;

CONTAINING

ALL THE INSTRUCTIONS REQUISITE FOR THE SKILFUL PRACTICE OF THIS ART.

WITH A NEW SET OF ACCURATE

MATHEMATICAL TABLES.

BY ROBERT GIBSON.

ILLUSTRATED BY COPPER-PLATES.

NEWLY ARRANGED, IMPROVED, AND ENLARGED, WITH USEFUL SELECTIONS,

BY JAMES RYAN,

AUTHOR OF AN ELEMENTARY TREATISE ON ALGEBRA; THE NEW AMERICAN GRAMMAR OF ASTRONOMY; THE DIFFERENTIAL AND INTEGRAL CALCULUS, &c. &c.

HARTFORD:
ALFRED S. BARNES & CO.
1839.

EXPLANATION

OF THE MATHEMATICAL CHARACTERS USED IN THIS WORK

$+$	signifies	*plus*, or addition.
$-$	"	*minus*, or subtraction.
$\times$ *or* .	"	multiplication.
$\div$	"	division.
: :: :	"	proportion.
$=$	"	equality.
$\sqrt{\ }$	"	square root.
$\sqrt[3]{\ }$	"	cube root, &c.
$\backsim$	"	difference between two numbers, when it is not known which is the greater.

Thus,

$5 + 3$, denotes that 3 is to be added to 5.
$6 - 2$, denotes that 2 is to be taken from 6.
7×3, or $7 . 3$, denotes that 7 is to be multiplied by 3.
$8 \div 4$, denotes that 8 is to be divided by 4.
$2 : 3 :: 4 : 6$, shows that 2 is to 3 as 4 is to 6.
$6 + 4 = 10$, shows that the sum of 6 and 4 is equal to 10.
$\sqrt{3}$, or $3^{\frac{1}{2}}$, denotes the square root of the number 3.
$\sqrt[3]{5}$, or $5^{\frac{1}{3}}$, denotes the cube root of the number 5.
7^2, denotes that the number 7 is to be squared.
8^3, denotes that the number 8 is to be cubed.

Et cætera.

CONTENTS.

THE

THEORY AND PRACTICE

OF

SURVEYING.

The word Surveying, in the mathematics, signifies the art of measuring land, and of delineating its boundaries on a map. The Surveyor, in the practice of this art, directs his attention, at first, to the tracing and measuring of lines; secondly, to the position of these lines in respect to each other, or the angles formed by them; thirdly, to the plan, or representation of the field or tract which he surveys; and fourthly, to the calculation of its area, or superficial content. When this art is employed in determining the variation of the compass, in observing and delineating coasts and harbours, their latitude, longitude, and soundings, together with the bearings of their most remarkable places from each other, it is usually denominated Maritime Surveying. This branch of Surveying, however, demands no other qualifications than those which should be thoroughly acquired by every land-surveyor who aspires to the character of an accomplished and skilful practitioner. Surveying, therefore, requires an intimate acquaintance with the several parts of the mathematics which are here inserted as an introduction to this treatise.

PART I.

Containing Decimal Fractions, Involution and Evolution, the Nature and Use of Logarithms, Geometry, and Plane Trigonometry.

SECTION I.

DECIMAL FRACTIONS.

If we suppose unity or any one thing to be divided into any assigned number of equal parts, this number is called the de-

nominator; and if we choose to take any number of such parts less than the whole, this is called the numerator of a fraction.

The numerator, in the vulgar form, is always written over the denominator, and these are separated by a small line thus $\frac{3}{4}$, or $\frac{5}{8}$; the first of these is called three-fourths, and the latter five-eighths, of an inch, yard, &c., or of whatever the whole thing originally consisted: the 4 and the 8 are the denominators, showing into how many equal parts the unit is divided; and the three and the five are the numerators, showing how many of those parts are under consideration.

Fractions are expressed in two forms, that is, either vulgarly or decimally.

All fractions whose denominators do not consist of a cipher or ciphers, set after unity, are called vulgar; and their denominators are always written under their numerators. The treatment of these, however, would be foreign to our present purpose. But fractions whose denominators consist of a unit prefixed to one or more ciphers, are called decimal fractions; the numerators of which are written without their denominators, and are distinguished from integers by a point prefixed; thus $\frac{2}{10}$, $\frac{42}{100}$, $\frac{172}{1000}$, in the decimal form, are expressed by .2, .42, .172.

The denominators of such fractions consisting always of a unit prefixed to as many ciphers as there are places of figures in the numerators, it follows, that any number of ciphers put after those numerators, will neither increase nor lessen their value: for $\frac{3}{10}$, $\frac{30}{100}$, and $\frac{300}{1000}$ are all of the same value, and will stand in the decimal form thus .3, .30, .300; but a cipher or ciphers prefixed to those numerators lessen their value in a tenfold proportion: for $\frac{3}{10}$, $\frac{03}{100}$, and $\frac{003}{1000}$, which in the decimal form we denote by .3, .03, and .003, are fractions, of which the first is ten times greater than the second; and the second, ten times greater than the third.

Hence it appears, that as the value and denomination of any figure, or number of figures, in common arithmetic is enlarged and becomes ten, or a hundred, or a thousand times greater, by placing one, or two, or three ciphers after it; so in decimal arithmetic, the value of any figure, or number of figures, decreases and becomes ten, or a hundred, or a thousand times less, while the denomination of it increases, and becomes so many times greater, by prefixing one, or two, or three ciphers to it: and that any number of ciphers before an integer, or after a decimal fraction, has no effect in changing its value

SCALE OF NOTATION.

Integers.							Decimals.					
7	3	4	2	1	8	6	8	7	5	3	2	6
millions.	hundreds of thousands.	tens of thousands.	thousands.	hundreds.	tens.	units.	tenth parts.	hundredth parts.	thousandth parts.	ten thousandth parts.	hundred thousandth parts.	millionth parts.

ADDITION OF DECIMALS.

Write the numbers under each other according to the value or denomination of their places; which position will bring all the decimal points into a column, or vertical line, by themselves. Then, beginning at the right-hand column of figures, add in the same manner as in whole numbers, and put the decimal point in the sum directly beneath the other points.

EXAMPLES.

Add 4.7832, 3.2543, 7.8251, 6.03, 2.857, and 3.251 together. Place them thus,

```
      4.7832
      3.2543
      7.8251
      6.03
      2.857
      3.251
     -------
Sum = 28.0006
```

Add 6.2, 121.306, .75, 2.7, and .0007 together.

```
      121.306
         .75
        2.7
         .0007
      --------
Sum = 130.9567
```

What is the sum of 6.57, 1.026, .75, 146.5, 8.7, 526., 2.97, and .0271?

Answer, 693.5431.

What is the sum of 4.51, 146.071, .507, .0006, 132., 62.71, .507, 7.9, and .10712?

Answer, 354.31272.

SUBTRACTION OF DECIMALS.

Write the figures of the subtrahend beneath those of the minuend according to the denomination of their places, as directed in the rule of addition; then, beginning at the right-hand, subtract as in whole numbers, and place the decimal point in the difference exactly under the other two points.

EXAMPLES.

From 38.765 take 25.3741
25.3741

Difference = 13.3909

From 2.4 take .8472
.8472

Diff. = 1.5528

From 71.45 take 8.4837248.
Difference = 62.9662752.

From 84 take 82.3412.
Diff. = 1.6588.

MULTIPLICATION OF DECIMALS.

Set the multiplier under the multiplicand without any regard to the situation of the decimal point; and having multiplied as in whole numbers, cut off as many places for decimals in the product, counting from the right-hand towards the left, as there are in both the multiplicand and multiplier: but if there be not a sufficient number of places in the product, the defect may be supplied by prefixing ciphers thereto.

For the denominator of the product being a unit, prefixed to as many ciphers as the denominators of the multiplier and multiplicand contain of ciphers, it follows that the places of decimals in the product will be as many as in the numbers from whence it arose.

EXAMPLES.

Multiply 48.765 by .003609.

```
            .003609
           ---------
             438885
            292590
           146295
           ---------
Product = .175992885
           ---------
```

```
   Multiply .121
         by .14
            ----
            484
           121
           -----
Product = .01694
           -----
```

```
Multiply 121.6 by 2.76
                  2.76
                 ------
                  7296
                 8512
                2432
                -------
     Product = 335.616
                -------
```

Multiply .0089789 by 1085.
Product = 9.7421065.

Multiply .248723 by .13587.
Product = .03379399401.

DIVISION OF DECIMALS.

Divide as in whole numbers; observing that the divisor and quotient together must contain as many decimal places as there are in the dividend. If, therefore, the dividend have just as many places of decimals as the divisor has, the quotient will be a whole number without any decimal figures. If there be more places of decimals in the dividend than there are in the divisor, point off as many figures in the quotient for decimals, as the decimal places in the dividend exceed those in the divisor; the want of places in the quotient being supplied by prefixing ciphers. But if there be more decimal places in the divisor than in the dividend, annex ciphers to the dividend, so that the decimal places here may be equal in number to those in the divisor; and then the quotient will be a whole number, without fractions.

When there is a remainder, after the division has been thus performed, annex ciphers to this remainder, and continue the operation till nothing remains, or till a sufficient number of decimals shall be found in the quotient.

EXAMPLES.

Divide .144 by .12.

```
.12).144(1.2 = quotient.
     12
     ---
      24
      24
      --
       0
```

Divide 63.72413456922 by 2718.

```
2718)63.72413456922(.02344522979 = quotient.
     5436
     ----
      9364
      8154
      -----
      12101
      10872
      -----
       12293
       10872
       -----
        14214
        13590
        -----
          6245
          5436
          ----
           8096
           5436
           -----
           26609
           24462
           -----
            21472
            19026
            -----
             24462
             24462
             -----
                 0
```

There being 11 decimal figures in the dividend, and none in the divisor, 11 figures are to be cut off in the quotient; but as the quotient itself consists of but 10 figures, prefix to them a cipher to complete that number.

Divide 1.728 by .012

```
.012)1.728(144 = quotient.—
     12
     ——
      52
      48
      ——
       48
       48
       ——
        0
```

Because the number of decimal figures in the divisor and dividend are alike, the quotient will be integers.

Divide 2 by 3.1416

```
3.1416)2.0000,0(0.636618+ = quotient.
       1 88496
       ———————
        115040
         94248
        ——————
        207920
        188496
        ——————
         194240
         188496
        ———————
          57440
          31416
         ——————
          260240
          251328
          ——————
            8912+
```

In this example there are four decimal figures in the divisor, and none in the dividend; therefore, according to the rule, four ciphers are annexed to the dividend, which, in this condition, is yet less than the divisor. A cipher must then be put in the quotient in the place of integers, and other ciphers annexed to the dividend; and the division being now performed, the decimal figures of the quotient are obtained.

Divide 7234.5 by 6.5 Quotient = 1113.
Divide 476.520 by .423 ——— = 1126.5+
Divide .45695 by 12.5 ——— = .0365+
Divide 2.3 by 96 ——— = .02395+
Divide 87446071 by .004387 — = 19933000000
Divide .624672 by 482 ——— = .001296.

REDUCTION OF DECIMALS

RULE I.

To reduce a Vulgar Fraction to a Decimal of the same value.

Having annexed a sufficient number of ciphers, as decimals, to the numerator of the vulgar fractions, divide by the denominator; and the quotient thence arising will be the decimal fraction required.

EXAMPLE.

Reduce $\frac{3}{4}$ to a decimal fraction.

4)3.00

.75=decimal required.

For $\frac{3}{4}$ of one acre, mile, yard, or any thing, is equal to $\frac{1}{4}$ of 3 acres, miles, yards, &c.; therefore if 3 be divided by 4, the quotient is the answer required.

Reduce $\frac{2}{5}$ to a decimal fraction. Answer .4
Reduce $\frac{12}{25}$ - - - - - - .48
Reduce $\frac{25}{218}$ - - - - - - .1146789
Reduce $\frac{7}{9}$ - - - - - - .7777+
Reduce $\frac{21}{23}$ - - - - - - .9130434+

Reduce $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, and so on to $\frac{1}{30}$, to their corresponding decimal fractions; and in this operation the various modes of interminate decimals may be easily observed.

RULE II.

To reduce Quantities of the same, or of different Denominations, to Decimal Fractions of higher Denominations.

If the given quantity consist of one denomination only, write it as the numerator of a vulgar fraction; then consider how many of this make one of the higher denomination, mentioned in the question, and write this latter number under the former, as the denominator of a vulgar fraction. When this has been done, divide the numerator by the denominator, as directed in the foregoing rule, and the quotient resulting will be the decimal fraction required.

But if the given quantity contain several denominations, reduce them to the lowest term for the numerator; reduce likewise that quantity whose fraction is sought to the same denomination, for the denominator of a vulgar fraction; then divide as before directed.

EXAMPLES.

Reduce 9 inches to the decimal of a foot.

The foot being equal to 12 inches, the vulgar fraction will be $\frac{9}{12}$; then 12)9.00

.75=decimal fraction required.

Reduce 8 inches to the decimal of a yard.

$$\frac{8 \text{ inches}}{1 \text{ yard} \times 3 \times 12 = 36}$$

36)8.0(.22+ = Answer.
7 2
——
80
72
——
8

Reduce 5 furlongs 00 perches to the decimal of a mile.

1 mile 5 furlongs
8 40
—— ——
8 fur. 200
40 $\frac{200}{320}$ = vulgar fraction.
——
320 per.

320)200.0(.625 = decimal sought.
192 0
——
800
640
——
1600
1600

Reduce 21 minutes 54 seconds to the decimal of a degree. Ans. .365.

Reduce .056 of a pole to the decimal of an acre. Ans. .00035.

Reduce 13 cents to the decimal of an eagle. Ans. .013.

Reduce 14 minutes to the decimal of a day. Ans. .00972+

Reduce 3 hours 46 minutes to the decimal of a week. Ans. 0224206+

RULE III

To find the value of Decimal Fractions in terms of the lower denominations.

Multiply the given decimal by the number of the next lower denomination which makes an integer of the present, and point off as many places at the right-hand of the product, for a remainder, as there are figures in the given decimal. Multiply this remainder by the number of the next inferior denomination, and point off a remainder as before. Proceed in this manner through all the parts of the integer, and the several denominations standing on the left-hand are the value required.

EXAMPLES.

Required the value of .3375 of an acre.

4 = number of roods in an acre.

1.3500

40 = number of perches in a rood.

14.0000

The value, therefore, is 1 rood 14 perches.

What is the value of .6875 of a yard?

3 = number of feet in a yard.

2.0625

12 = number of inches in a foot.

.7500

12 = number of lines in an inch.

9.0000

The answer here is 2 feet 9 lines.

What is the value of .084 of a furlong? Ans. 3 per. 1 yd. 2 ft. 11 in.

What is the value of .688 of a degree? Ans. 40 m. 58 sec. 48 thirds.

What is the value of .0053 of a mile? Ans. 1 per. 3 yds. 2 ft. 5 in.+

What is the value of .036 of a day? Ans. 51′ 50″ 24‴.

PROPORTION IN DECIMAL FRACTIONS.

Having reduced all the fractional parts in the given quantities to their corresponding decimals, and having stated the three known terms, so that the fourth, or required quantity, may be as much greater or less than the third as the second term is greater or less than the first, then multiply the second and third terms together, and divide the product by the first term, and the quotient will be the answer;—in the same denomination with the third term.

EXAMPLES.

If 3 acres 3 roods of land can be purchased for 93 dollars 60 cents, how much will 15 acres 1 rood cost at that rate?

3 acs. 3 rds. = 3.75 acres.
15 acs. 1 rd. = 15.25 acres.
$93, 60 cents =$93.60

Then 3.75 : 15.25 : : 93.60 :

```
                 15.25
                 -----
                 46800
                18720
               46800
               9360
               -------         $
      3.75)1427.4000(380.64 = Answer.
           1125
           ----
           3024
           3000
           ----
            2400
            2250
            ----
             1500
             1500
```

If a clock gain 14 seconds in 5 days 6 hours, how much will it gain in 17 days 15 hours? Ans. 47 seconds

If 187 dollars 85 cents gain 12 dollars 33 cents interest in a year, at what rate per cent. is this interest? Ans. 6.56+

SECTION II.

INVOLUTION AND EVOLUTION.

INVOLUTION is the method of raising any number, considered as the root, to any required power.

Any number, whether given or assumed at pleasure, may be called the root or first power of this number; and its other powers are the products that result from multiplying the number by itself, and the last product by the same number again, and so on to any number of multiplications.

The index, or exponent, is the number denoting the height, or degree of the power, being always greater by one than the number of multiplications employed in producing the power. It is usually written above the root, as in the following EXAMPLE, where the method of involution is plainly exhibited.

Required the fifth power of 8 = the root, or first power.
first multiply by - - 8

then multiply the product 64 = 8^2 = square, or second power.
by 8

&c. 512 = 8^3 = cube, or third power.
8

4096 = 8^4 = biquadrate, or fourth power.
8

32768 = 8^5 = Answer.

EXAMPLES FOR EXERCISE.

What is the second power of 3.05? Ans. 9.3025.
What is the third power of 85.3? Ans. 620650.477.
What is the fourth power of .073? Ans. .000028398241.
What is the eighth power of .09? Ans. .00.00.00.0043046721.

Note.—When two or more powers are multiplied together, their product is that power whose index is the sum of the indices of the factors, or powers multiplied.

EVOLUTION is the method of extracting any required root from any given power.

Any number may be considered as a power of some other number; and the required root of any given power is that

number which being multiplied into itself a particular number of times produces the given power; thus if 81 be the given number, or power, its square or second root is 9; because $9\times 9=9^2=81$; and 3 is its biquadrate, or fourth root, because $3\times 3\times 3\times 3=3^4=81$. Again, if 729 be the given power, and its cube root be required, the answer is 9, for $9\times 9\times 9=729$; and if the sixth root of that number be required, it is found to be 3, for $3\times 3\times 3\times 3\times 3\times 3=729$.

The required power of any given number, or root, can always be obtained exactly, by multiplying the number continually into itself; but there are many numbers from which a proposed root can never be completely extracted;—yet by approximating with decimals, these roots may be found as exact as necessity requires. The roots that are found complete are denominated *rational* roots, and those which cannot be found completed, or which only approximate, are called *surd*, or irrational roots.

Roots are usually represented by these characters or exponents:

$\sqrt{\ }$, or $^{\frac{1}{2}}$ which signifies the square root; thus, $\sqrt{9}$, or $9^{\frac{1}{2}}=3$.

$\sqrt[3]{\ }$ or $^{\frac{1}{3}}$ cube root; $\sqrt[3]{64}$, or $64^{\frac{1}{3}}=4$.

$\sqrt[4]{\ }$ or $^{\frac{1}{4}}$ biquadrate root; $\sqrt[4]{16}$, or $16^{\frac{1}{4}}=2$, &c.

Likewise $8^{\frac{3}{2}}$ signifies the square root of 8 cubed; and, in general, the fractional indices imply that the given numbers are to be raised to such powers as are denoted by their numerators, and that such roots are to be extracted from these powers as are denoted by their denominators.

RULE

For extracting the Square Root.

Commencing at the unit figure, cut off periods of two figures each, till all the figures of the given number are exhausted.*

The first figure of the required root will be the square root

* In dividing a decimal, or a number consisting of a whole number with a decimal, into periods, the division must also commence at the unit figure or decimal point, and must be continued both ways, if there be a whole number; and if there be an odd figure at the end of the decimal, a cipher, or if it be a periodical decimal, the figure that would next arise, from its continuation, must be annexed; thus 417.245 will be divided thus, 4′17′.24′50: 41.66666, &c. thus, 41′.66′66′66: and .567 thus, 56′70, &c.

See the Editor's "*Elementary Treatise on Arithmetic, in Theory and Practice,*" page 219.—Ed.

of the first period, or of the greatest square root contained in it, if it be not a square itself.

Subtract the square of this figure from the first period; to the remainder annex the next period for a dividend; and for part of a divisor, double the part of the root already obtained.

Try how often this part of the divisor is contained in the dividend wanting the last figure, and annex the figures thus found to the parts of the root and of the divisor already determined.

Thus multiply and subtract as in division; to the remainder bring down the next period, and, adding to the divisor the figure of the root last found, proceed as before.*

If any thing remain after continuing the process till all the figures in the given number have been used, proceed in the same manner to find decimals, adding, to find each figure, two ciphers, or if the given number end in an interminate decimal, the two figures that would next arise from its continuation.

To extract the root of a fraction, reduce it to its simplest form, if it be not so already, and extract the root of both terms, if they be complete powers: otherwise divide the root of their product by the denominator.

The root may also be found by reducing the fraction to a decimal, if it be not such already, and taking the root of the decimal.

EXAMPLES.

Required the square root of 1710864.

	1'71'08'64'
1	1710864(1308 = Answer.
1	1
23	71
3	69
2608	20864
	20864

* *The principle* on which the preceding rule depends is, *that the square of the sum of two numbers is equal to the squares of the numbers with twice their product.* Thus, the square of 34 is equal to the squares of 30 and of 4 with twice the product of 30 and 4; that is, to $900+2\times30\times4+16=1156$. Here, in extracting the second root of 1156, we separate it into two parts, 1100 and 56. Thus 1100 contains 900, the square of 30, with the remainder 200; the first part of the root is therefore 30, and the remainder $200+56$, or 256. Now, according to the principle above men-

Required the square root of 16007.3104.

```
        | 1'60'07'.31'04
     1  | 16007.3104(126.52 = Answer.
     1  | 1
       -------
    22  | 60
     2  | 44
       -------
   246  | 1607
     6  | 1476
       -------
  2525  | 13131
     5  | 12625
       -------
 25302  | 50604
        | 50604
```

EXAMPLES FOR EXERCISE.

Required the square root of 298116. Ans. 546.
Required the square root of 348.17320836. Ans. 18.6594.
Required the square root of 17.3056. Ans. 4.16.
Required the square root of .000729. Ans. .027.
Required the square root of $17\frac{3}{8}$. Ans. 4.168333+

TO EXTRACT THE CUBE ROOT.

RULE I.—Commencing at the unit figure, cut off periods of three figures each, till all the figures of the given number are exhausted. Then find the greatest cube number contained in the *first* period, and place the cube root of it in the quotient. Subtract its cube from the first period, and bring down the next three figures; divide the number thus brought down by 300 times the square of the first figure of the root, and it will give the second figure; add 300 times the square of the first figure, 30 times the product of the first and second figures, and the square of the second figure together, for a divisor; then

tioned, this remainder must be twice the product of 30, and the part of the root still to be found, together with the square of that part. Now, dividing 256 by 60, the double of 30, we find for quotient 4; then this part being added to 60, the sum is 64, which being multiplied by 4, the product 256 is evidently twice the product of 30 and 4, together with the square of 4. In the same manner the operation may be illustrated in every case. The rule, however, is best demonstrated by Algebra.

See my Treatise on this subject, page 231, second edition.—ED.

multiply this divisor by the second figure, and subtract the result from the dividend, and then bring down the next period, and so proceed till all the periods are brought down.*

To extract the cube root of a fraction, reduce it to a decimal, and then extract the root; or multiply the numerator by the square of the denominator, find the cube root of the product, and divide by the denominator.

The cube root of a mixed number is generally best found by reducing the fractional part to a decimal, if it be not so already, and then extracting the root. It may be also found by reducing the given number to an improper fraction, and then working according to the preceding directions.

EXAMPLES.

1. Required the cube root of 48228.544.

$3^2 \times 300 = 2700$	48′228′.544′(36.41 Root.
$3 \times 30 = 90$	27
Divisor 2790	21228 Resolvend.
	19656 Subtrahend.
$3^2 \times 300 \times 6 = 16200$	
$3 \times 30 \times 6^2 = 3240$	1572.544 Resolvend.
$6^3 = 216$	1572.544 Subtrahend.
Subtrahend 19656	
$36^2 \times 300 = 388800$	
$36 \times 30 = 1080$	
Divisor 389880	
$36^2 \times 300 \times 4 = 1555200$	
$36 \times 30 \times 4^2 = 17280$	
$4^3 = 64$	
Subtrahend .1572544	

Ex. 2. What is the cube root of 62570773? Ans. 397.
Ex. 3. What is the cube root of 51478848? Ans. 372.
Ex. 4. What is the cube root of 84.604519? Ans. 4.39.
Ex. 5. What is the cube root of 16974593? Ans. 257.

* The reason of this rule will appear evident from the following illustration. The cube of 25, for instance, is equivalent to the cube of 20 added to the cube of 5, together with the sum of $300 \times 4 \times 5 + 30 \times 2 \times 5 \times 5$, or, which is the same thing, 25 is equal to 20+5, and therefore 25 cubed

2. *To extract the Cube Root by another Method.**

1. By trials find the nearest rational cube to the given number, whether it be greater or less, and call it the assumed cube.

2. Then say, by the Rule of Three, as the sum of the given number and double the assumed cube is to the sum of the assumed, and double the given number, so is the root of the assumed cube to the root required, nearly. Or, as the first sum is to the difference of the given and assumed cube, so is the assumed root to the difference of the roots, nearly.

3. By using, in like manner, the cube of the root last found as a new assumed cube, another root will be obtained still nearer. And so on as far as we please; using always the cube of the last found root for the assumed cube.

EXAMPLES.

1. To find the cube root of 21035.8.

Here the root is soon found between 27 and 28. Taking therefore 27, its cube is 19683, which is the assumed cube. Then,

$$\begin{array}{rr} 19683 & 21035.8 \\ 2 & 2 \\ \hline 39366 & 42071.6 \\ 21035.8 & 19683 \\ \hline \end{array}$$

As 60401.8 : 61754.6 : : 27 : 27.6047,

---

is equal to $20+5$ cubed; but $20+5$ cubed is equivalent to $8000+300\times4\times5+30\times2\times5\times5+125$, or to $20^3+(300\times4+30\times2\times5+5\times5)\times5=$ 48228544.

$$\text{Thus,}\quad \left.\begin{array}{l} 20+5 \\ 20+5 \end{array}\right\}\text{Multiplied.}$$

$$\begin{array}{l} \hline 20\times20+5\times20 \\ \qquad\quad +5\times20+25 \\ \hline \end{array}$$

$$\text{Multiplied,}\left\{\begin{array}{l} 20\times20+2\times5\times20+25=\text{second power.} \\ 20+5 \end{array}\right.$$

$$\begin{array}{l} \hline 20\times20\times20+2\times5\times20\times20+20\times25 \\ \qquad\qquad\qquad +5\times20\times20+2\times20\times25+125 \\ \hline 20\times20\times20+3\times5\times20\times20+3\times20\times25+125=\text{3d power} \\ \text{or, } 8000+300\times4\times5+30\times2\times25+125. \end{array}$$

Here the rule is evident. In the same manner, the operation may be illustrated in every case. For a demonstration of this rule in general terms, the reader is referred to the Editor's "Treatise on Algebra, Theoretical and Practical."—Ed.

* This rule is found in Hutton's Mathematics. There have been different rules given for extracting the cube root, among which this, and another rule given in Pike's Arithmetic (by approximation), are very expeditious.

Therefore 27.6047 is the root nearly.

Again, by repeating the operation, and taking 27.6047 for the assumed root, it will give 27.60491 the root still nearer.

2. Required the cube root of 3214? Ans. 14.75758.
3. Required the cube root of 2? Ans. 1.25992.
4. Required the cube root of 256? Ans. 6.349.

SECTION III.

OF LOGARITHMS.

Logarithms are a series of numbers, so contrived, that by them the work of multiplication may be performed by addition; and the operation of division may be done by subtraction. Or, —Logarithms are the indices, or series of numbers in arithmetical progression, corresponding to another series of numbers in geometrical progression. Thus,

0, 1, 2, 3, 4, 5, 6, &c. indices or logarithms.
1, 2, 4, 8, 16, 32, 64, &c. geometrical progression.

Or,

0, 1, 2, 3, 4, 5, 6, &c. ind. or log.
1, 3, 9, 27, 81, 243, 729, &c. geometrical series.

Or,

0*, 1, 2, 3, 4, 5, 6, &c. ind. or log.
1, 10, 100, 1000, 10000, 100000, 1000000, &c. geometrical series,—where the same indices serve equally for any geometrical series or progression.

Hence it appears that there may be as many kinds of indices, or logarithms, as there can be taken kinds of geometrical series. But the logarithms most convenient for common uses are those adapted to a geometrical series increasing in a tenfold progression, as in the last of the foregoing examples.

In the geometrical series 1, 10, 100, 1000, &c. if between the terms 1 and 10 the numbers 2, 3, 4, 5, 6, 7, 8, 9 were interposed, indices might also be adapted to them in an arith-

* In any system of logarithms the log. of 1 is 0; for logarithms may be considered as the exponents of the powers to which a given or invariable number must be raised, in order to produce all the common or natural numbers, therefore by assuming $x^0=a$, then by squaring $x^0=a^2$ hence $a^2=a$, and consequently by division $a=1$, from whence it is evident that the log. of 1 is always $= 0$, in any system; for more on this subject, and the algebraical form of the rule for computing logarithms, see Bonnycastle's Algebra, page 200, New-York edition; or my Treatise on Algebra, page 332, second edition.—Ed.

metical progression, suited to the terms interposed between 1 and 10, considered as a geometrical progression. Moreover, proper indices may be found to all the numbers, that can be interposed between any two terms of the geometrical series.

But it is evident that all the indices to the numbers under 10, must be less than 1; that is, they must be fractions. Those to the numbers between 10 and 100, must fall between 1 and 2; that is, they are mixed numbers, consisting of one and some fraction. Likewise the indices to the numbers between 100 and 1000, will fall between 2 and 3; that is, they are mixed numbers, consisting of 2 and some fraction; and so of the other indices.

Hereafter the integral part only of these indices will be called the index; and the fractional part will be called the logarithm. The computation of these fractional parts is called *making logarithms*; and the most troublesome part of this work is to make the logarithms *of prime numbers*, or those which cannot be divided by any other numbers than themselves and unity.

RULE

*For computing the Logarithms of Numbers.**

Let the sum of its proposed number and the next less number be called A. Divide 0.8685889638+ by A, and reserve

* The number 0.8685889638+ is twice the reciprocal of the hyperbolic log. 2.302585093, which is the log. of 10, according to the first form of Lord Napier, the inventor of logarithms; which log. according to the excellent Sir I. Newton's method is calculated thus; let DFD (Pl. 14, *fig.* 1) be an hyperbola whose centre is C, vertex F, and interposed square CAFE=1. In CA take AB and Ab, on each side $= \frac{1}{10}$, or 0.1 and, erecting the perpendiculars BD, bd, half the sum of the spaces AD and Ad will be $=0.1+\frac{0.001}{3}+\frac{0.00001}{5}+\frac{0.0000001}{7}$, &c.
and the half diff. $=\frac{0.01}{2}+\frac{0.0001}{4}+\frac{0.000001}{6}+\frac{0.00000001}{8}$, &c.
Which reduced will stand thus,

0.1000000000000,	0.0050000000000	Sum of these=0.1053605156577=A*d*
3333333333	250000000	And the diff.=0.0953101798043=AD
20000000	1666666	In like manner putting AB and A*b*
142857	12500	each = 0.2 there is obtained
1111	100	A*d* = 0.2231435513142, and
9	1	AD = 0.1823215567939.
0.1003353477310,	0.0050251679267	

Having thus the hyperbolic logarithms of the four decimal numbers 0.8, 0.9, 1.1, and 1.2; and since $\frac{1.2}{0.8}\times\frac{1.2}{0.9}=2$, and 0.8 and 0.9 are less than unity, adding their logarithms to double the log. of 1.2, we have 0.6931471805607, the hyperbolic log. of 2. To the triple of this adding the log. of 0.8, because $\frac{2\times2\times2}{0.8}=10$, we have 2.3025850929933, the log. of 10. Hence by one addition

the quotient. Divide the reserved quotient by the square of A, and reserve this quotient. Divide the last reserved quotient by the square of A, reserving the quotient still; and thus proceed as long as division can be made. Write the reserved quotients orderly under one another, the first being uppermost. Divide these quotients respectively by the odd numbers 1, 3, 5, 7, 9, 11, &c.; that is, divide the first reserved quotient by 1, the second by 3, the third by 5, the fourth by 7, &c., and let these quotients be written orderly under one another; add them together, and their sum will be a logarithm. To this logarithm add the logarithm of the next less number, and the sum will be the logarithm of the number proposed.

EXAMPLE 1.

Required the logarithm of the number 2.

Here the next less number is 1, and $2+1=3=A$, and A^2 or $3^2=9$; then

$$
\begin{array}{l}
3)0.868588964 \\
\hline
9)0.289529654 \div 1 = 0.289529654 \\
\hline
9)0.032169962 \div 3 = 0.010723321 \\
\hline
9)0.003574440 \div 5 = 0.000714888 \\
\hline
9)0.000397160 \div 7 = 0.000056737 \\
\hline
9)0.000044129 \div 9 = 0.000004903 \\
\hline
9)0.000004903 \div 11 = 0.000000446 \\
\hline
9)0.000000545 \div 13 = 0.000000042 \\
\hline
\quad 0.000000061 \div 15 = 0.000000004 \\
\end{array}
$$

are found the logarithms of 9 and 11: And thus the logarithms of all the prime numbers are prepared, that is, 2, 3, 5, 11, &c.

Moreover, by only depressing the numbers above computed, lower in the decimal places, and adding, are obtained the logarithms of the decimals 0.98, 0.99, 1.01, 1.02; as also of these, 0.998, 0.999, 1.001, 1.002. And hence, by addition and subtraction, will arise the logarithms of the primes 7, 13, 17, 37, &c. All which logarithms being divided by 2.302585092993 (the hyperbolic log. of 10), or multiplied by its reciprocal, .4342944819, give the common logarithms to be inserted in the table.

Note.—For further illustration on this subject, the reader is referred to Hutton's Tables.

To this logarithm 0.301029995
add the logarithm of 1=0.000000000

Their sum=0.301029995=log. of 2.

The manner in which the division is here carried on may be readily perceived by dividing, in the first place, the given decimal by A, and the succeeding quotients by A^2; then letting these quotients remain in their situation, as seen in the example, divide them respectively by the odd numbers, and place the new quotients in a column by themselves. By employing this process, the operation is considerably abbreviated.

EXAMPLE 2.

Required the logarithm of the number 3.

Here the next less number is 2; and $3+2=5=A$, and $A^2=25$.

5)0.868588964

25)0.173717793 ÷ 1=0.173717793

25)0.006948712 ÷ 3=0.002316237

25)0.000277948 ÷ 5=0.000055590

25)0.000011118 ÷ 7=0.000001588

25)0.000000445 ÷ 9=0.000000049

0.000000018 ÷ 11=0.000000002

To this logarithm 0.176091259
add the logarithm of 2=0.301029995

Their sum=0.477121254=log. of 3.

Then, because the sum of the logarithms of numbers gives the logarithm of their product; and the difference of the logarithms gives the logarithm of the quotient of the numbers: from the two preceding logarithms, and the logarithm of 10, which is 1, a great many logarithms can be easily made, as in the following examples.

Example 3. Required the logarithm of 4.

Since $4=2\times 2$, then to the logarithm of 2=0.301029995
add the logarithm of 2=0.301029995

The sum=logarithm of 4=0.602059990

Example 4. Required the logarithm of 5.

10÷2 being =5, therefore from the logarithm of

10=1.000000000

subtract the logarithm of 2=0.301029995

the remainder is the logarithm of 5=0.698970005

Example 5. Required the logarithm of 6.

6=3×2, therefore to the logarithm of 3=0.477121254

add the logarithm of 2=0.301029995

their sum = logarithm of 6=0.778151249

Example 6. Required the logarithm of 8.

$8=2^3$, therefore multiply the logarithm of 2=0.301029995

by 3

The product = logarithm of 8=0.903089985

Example 7. Required the logarithm of 9.

$9=3^2$, therefore the logarithm of 3=0.477121254

being multiplied by 2

the product = logarithm of 9=0.954242508

Example 8. Required the logarithm of 7.

Here the next less number is 6, and 7+6=13=A, and $A^2=169$.

13)0.868588964

169)0.066814536÷1=0.066814536

169)0.000395352÷3=0.000131784

169)0.000002339÷5=0.000000468

0.000000014÷7=0.000000002

To this logarithm =0.066946790

add the logarithm of 6=0.778151249

Their sum = 0.845098039 = logarithm of 7.

The logarithm	of 12	is equal to the sum of the logarithms	of 3 and 4
	of 14		of 7 and 2.
	of 15		of 3 and 5.
	of 16		of 4 and 4.
	of 18		of 3 and 6.
	of 20		of 4 and 5.

The logarithms of the prime numbers 11, 13, 17, 19, &c. being computed by the foregoing general rule, the logarithms of the intermediate numbers are easily found by composition and division. It may however be observed, that the operation is shorter in the larger prime numbers; for when any given number exceeds 400, the first quotient being added to the logarithm of its next lesser number, will give the logarithm sought, true to eight or nine places; and therefore it will be very easy to examine any suspected logarithm in the Tables.

For the arrangement of logarithms in a table, the method of finding the logarithm of any natural number, and of finding the natural number corresponding to any given logarithm therein,—likewise for particular rules concerning the indices, the reader will consult Table 1, with its explanation at the end of this treatise.

MULTIPLICATION.

Two or more numbers being given, to find their product by Logarithms.

RULE.

Having found the logarithms of the given numbers in the table, add them together, and their sum is the logarithm of the product; which logarithm being found in the table, will give a natural number, that is, the product required.

Whatever is carried from the decimal part of the logarithm is to be added to the affirmative indices, but subtracted from the negative. Likewise the indices must be added together when they are all of the same kind, that is, when they are all affirmative, or all negative; but when they are of different kinds, the difference must be found, which will be of the same denomination with the greater.

Example 1. Required the product of 86.25 multiplied by 6.48.

Log. of 86.25 = 1.935759
Log. of 6.48 = 0.811575

Product = 558.9 = 2.747334*

* For the method of finding the natural number, answering to the sum of the logarithms, the reader will consult Table 1, at the end of this treatise.

Example 2. Required the product of 46.75 and .3275.

Log. of 46.75 = 1.669782
Log. of .3275 = —1.515211

Product = 15.31+ = 1.184993

Here the +1 that is to be carried from the decimals cancels the —1, and consequently there remains 1 in the upper line to be set down.

Example 3. Required the product of 3.768, 2.053, and .007693.

Log. of 3.768 = 0.576111
Log. of 2.053 = 0.312389
Log. of .007693 = —3.886096

Product = .05951+ = —2.774596

In this example there is 1 to carry from the decimal part of the logarithms, which, subtracted from —3, the negative index, leaves 2, the index of the sum of the logarithms, and is negative.

Example 4. Required the product of 27.63, 1.859, .7258, and 0.3591.

Log. of 27.63 = 1.441381
Log. of 1.859 = 0.269279
Log. of .7258 = —1.860817
Log. of .03591 = —2.555215

Product nearly = 1.339 = 0.126692

In this example there is 2 to carry from the decimal part of the logarithms, which added to 1, the affirmative index, makes 3, from this take 3, the sum of the negative indices, the remainder is 0, which is the index of the sum of the logarithms.

5. Required the product of 23.14 and 50.62, by logarithms.
Ans. 117.1347

6. Required the product of 3.12567, .02868, and .12379, by logarithms. Ans. .01109705

7. Required the product of .1508, .0139, and 756.9, by logarithms. Ans. 1.586553

8. Required the product of 637.8 and 89.27, by logarithms.
Ans. 56936.406

9. Required the product of 14 and 8.45, by logarithms.
Ans. 118.30

DIVISION.

Two numbers being given, to find how many times one is contained in the other by Logarithms.

RULE.

From the logarithm of the dividend subtract the logarithm of the divisor, and the remainder will be the logarithm whose corresponding natural number will be the quotient required.

In this operation, the index of the divisor must be changed from affirmative to negative, or from negative to affirmative; and then the difference of the affirmative and negative indices must be taken for the index to the logarithm of the quotient. Likewise when 1 has been borrowed in the left-hand place of the decimal part of the logarithm, add it to the index of the divisor, if affirmative; but subtract it, if negative; and let the index thence arising be changed and worked with as before.

Example 1. Divide 558.9 by 6.48.

Log. of 558.9 =	2.747334
Log. of 6.48 =	0.811575
Quotient = 85.25 =	1.935759

Here, the 1 to be taken from the decimals is taken as —1, which when added to 2, the index of the dividend, leaves 1 for the index of the quotient; that is, 2—1=1.

Example 2. Divide 15.31 by 46.75.

Log. of 15.31 =	1.184975
Log. of 46.75 =	1.669782
Quotient =.3275 =	—1.515193

Here, the 1 to be taken from the decimals is added to 1, the index of the divisor makes 2; this with its sign changed is —2, from which subtracting 1, the index of the dividend, the remainder is —1, which is negative, because the negative index is greater.

Example 3. Divide .05951 by .007693.

Log. of .05951 =	—2.774590
Log. of .007693 =	—3.886096
Quotient = 7.735 =	0.888494

Here, the 1 to be taken from the decimals is subtracted from —3, which leave —2, this changed is +2; and this added to —2, the other index, gives 2—2=0.

Example 4. Divide .6651 by 22.5.

$$\begin{array}{lr} \text{Log. of } .6651 = & -1.822887 \\ \text{Log. of } 22.5 = & 1.352183 \\ \hline \text{Quotient} = .02956 = & -2.470704 \end{array}$$

Here, +1 in the lower index, is changed into —1, and this added to —1, the other index, gives —1—1, or —2, the index of the result.

5. Required the quotient of 125 divided by 1728, by logarithms. Ans. .0723379

6. Divide 1728.95 by 1.10678, by logarithms. Ans. 1562.144

7. Divide .067859 by 1234.59, by logarithms. Ans. .0000549648

8. Divide .7438 by 12.9470, by logarithms. Ans. .057449

9. Divide .06314 by .007241, by logarithms. Ans. 8.71979

PROPORTION,

Or the Rule of Proportion in Logarithms.

RULE.

Having stated the three given terms according to the rule in common Arithmetic, write them orderly under one another, with the signs of proportion; then add the logarithms of the second and third terms together, and from their sum subtract the logarithm of the first term, and the remainder will be the logarithm of the fourth term, or answer.

Or,—add together the arithmetical complement of the logarithm of the first term, and the logarithms of the second and third terms; the sum, rejecting 10 from the index, will be the logarithm of the fourth term, or term required.

N.B. The arithmetical complement of a logarithm is what it wants of 10,000000, or 20,000000, and the easiest way to find it is to begin at the left-hand, and subtract every figure from 9, except the last, which should be taken from 10; but if the index exceed 9, it must be taken from 19.—It is frequently used in the rule of Proportion and Trigonometrical calculations, to change subtractions into additions.*

* When the index is negative add it to 9, and subtract as before. And for every arithmetical complement that is added, subtract 10 from the last sum of the indices.

EXAMPLES.

1st. If a clock gain 14 seconds in 5 days 18 hours, how much will it gain in 17 days 15 hours?

5.75 days : Log. = 0.759668

17.625 days :: Log. = 1.246129
14 seconds . : Log. = 1.146128

2.392257

Answer = 42″. 91 = 1.632589

Or thus; 5.75 days: Arith. Co. Log. = 9.240332
17.625 :: Log. = 1.246129
14 seconds : Log. = 1.146128

Answer = 42″.91 = 1.632589

2d. Find a fourth proportional to 98.45, 1.969, and 347.2.

98.45 : Log. = 1.993216

347.2 :: Log. = 2.540580
1.969 : Log. = 0.294246

2.834826

Answer = 6.944 = 0.841610

3d. What number will have the same proportion to .8538 as .3275 has to .0131?

.0131 : Log. = —2.117271

.3275 :: Log. = —1.515211
.8538 : Log. = —1.931356

—1.446567

Answer = 21.35 = 1.329296

4th. Required a third proportional number to 9.642 and 4.821

9.642 : Log. = 0.984167

4.821 :: Log. = 0.683137
4.821 : Log. = 0.683137

1.366274

Answer = 2.411 = 0.382107

5. Find a fourth proportional to .05764, .7186, and .34721 by logarithms. Ans. 4.328681.

6. Find a fourth proportional to 12.687, 14.065, and 100.979, by logarithms. Ans. 112.0263.

7. Find a mean proportional between 8.76 and 43.5, by logarithms. Ans. 16.7051.

8. Find a third proportional to 12.796 and 3.24718, by logarithms. Ans. .8240216.

9. If the interest of £100 for a year, or 365 days, be £4.5, what will be the interest of £279.25 for 274 days?

Ans. £9.433294.

INVOLUTION.

To find any proposed power of a given number by Logarithms.

RULE.

Multiply the logarithm of the given number by the index of the proposed power. and the product will be the logarithm whose natural number is the power required.

When a negative index is thus multiplied, its product is negative, but what was carried from the decimal part of the logarithm must be affirmative; consequently the difference is the index of the product, which difference must be considered of the same kind with the greater, or that which was made the minuend.

EXAMPLES.

1. What is the second power of 3.874?

Log. of 3.874 = 0.588160
Index = 2

Power required = 15.01 = 1.176320

2. Required the third power of the number 2.768.

Log. of 2.768 = 0.442166
Index = 3

Answer = 21.21 = 1.326498

3. Required the second power of the number .2857.

Log. of .2857 = —1.455910
Index = 2

Answer = .08162 = —2.911820

4. Required the third power of the number .7916.

Log. of .7916	=	—1.898506
Index	=	3
Answer = .4961	=	—1.695518

Hence, 3 times the negative index being —3, and 2 to carry from the decimals, the difference is —1, the index of the product.

5. To find the 4th power of .09163. Ans. .000070494.
6. To find the 2d power of 6.05987. Ans. 36.72203.
7. To find the cube of 3.07146. Ans. 28.97575.
8. To find the 7th power of 1.09684. Ans. 1.909864.
9. To find the 365th power of 1.0045. Ans. 5.148888.

EVOLUTION.

To extract any proposed Root of a given number by Logarithms.

RULE.

Find the logarithm of the given number, and divide it by the index of the proposed root; the quotient is a logarithm whose natural number is the root required.

When the index of the logarithm to be divided is negative, and does not exactly contain the divisor without some remainder, increase the index by such a number as will make it exactly divisible by the index, carrying the units borrowed as so many tens to the left-hand place of the decimal, and then divide as in whole numbers.

EXAMPLES.

1. Required the square root of 847.
Index 2)2.927883 = log. of 847.

1.463941 = quot. = log. of 29.103+ = Ans.

2. Required the cube root of 847.
Index 3)2.927883 = log. of the given number.

0.975961 = quot. = log. of 9.462 = Ans. nearly

3. Required the square root of .093.
Index 2)—2.968483 = log. of .093.

—1.484241 = quot. = log. of .304959 = Ans.

4. Required the cube root of 12345.
Index 3)4.091491 = log. of 12345.

1.363830 = quot. = log of 23.116 = Ans.

5. To find the cube root of .00048
Power, or index 3)$\bar{4}.6812412$ = log. of the number.

Root .07829735.....$\bar{2}.8937471$ = log. of the root.

Here the divisor 3 not being exactly contained in $\bar{4}$, augment it by 2, to make it become $\bar{6}$, in which the divisor is contained just 2 times; and the 2 borrowed being prefixed to the other figures, makes 2.6812412, which divided by 3 gives .8937471; therefore, $\bar{2}.8937471$ is the log. of the root.

6. To find the fourth root of .967845, by logarithms. Ans. .9918624.

7. To find the cube root of 2.987635. Ans. 1.440265.

8. To find the cube root of $\frac{1}{3.14159}$. Ans. .6827842.

9. To find the value of $(.001234)^{\frac{2}{3}}$. Ans. .0115047.

10. To find the tenth root of 2. Ans. 1.071773.

SECTION IV.

ELEMENTS OF PLANE GEOMETRY.

DEFINITIONS.

See PLATE I.

1. GEOMETRY is that science wherein we consider the properties of magnitude.

2. A point is that which has no parts, being of itself indivisible; as *A*.

3. A line has length but no breadth; as *AB*, figures 1 and 2.

4. The extremities of a line are points, as the extremities of the line *AB* are the points *A* and *B*, figures 1 and 2.

5. A right line is the shortest that can be drawn between any two points, as the line *AB*, fig. 1; but if it be not the shortest, it is then called a curve line, as *AB*, fig. 2.

6. A superficies or surface is considered only as having length and breadth, without thickness, as *ABCD*, fig. 3.

7. The extremities of a superficies are lines.

8. The inclination of two lines meeting one another (provided they do not make one continued line), or the opening between them, is called an angle. Thus in fig. 4 the inclination of the

line *AB* to the line *BC*, meeting each other in the point *B*, or the opening of the two lines *BA* and *BC*, is called an angle, as *ABC*.

Note.—When an angle is expressed by three letters, the middle one is that at the angular point.

9. When the lines that form the angle are right ones, it is then called a right-lined angle, as *ABC*, fig. 4. If one of them be right and the other curved, it is called a mixed angle, as *B*, fig. 5. If both of them be curved, it is called a curved-lined or spherical angle, as *C*, fig. 6.

10. If a right line *CD* (fig. 7) fall upon another right line *AB*, so as to incline to neither side, but make the angles *ADC*, *CDB*, on each side equal to each other, then those angles are called right angles, and the line *CD* a perpendicular.

11. An obtuse angle is that which is wider or greater than a right one, as the angle *ADE*, fig. 7, and an acute angle is less than a right one, as *EDB*, fig. 7.

12. Acute and obtuse angles in general are called oblique angles.

13. If a right line *CB*, fig. 8, be fastened at the end *C*, and the other end *B* be carried quite round, then the space comprehended is called a circle; and the curve line described by the point *B* is called the circumference or the periphery of the circle; the fixed point *C* is called its centre.

14. The describing line *CB*, fig. 8, is called the semidiameter or radius; so is any line from the centre to the circumference; whence all radii of the same or of equal circles are equal.

15. The diameter of a circle is a right line drawn through the centre, and terminating in opposite points of the circumference; and it divides the circle and circumference into two equal parts, called semicircles; and is double the radius, as *AB* or *DE*, fig. 8.

16. The circumference of every circle is supposed to be divided into 360 equal parts called degrees, and each degree into 60 equal parts called minutes, and each minute into 60 equal parts called seconds, and these into thirds, fourths, &c. these parts being greater or less as the radius is.

17. A chord is a right line drawn from one end of an arc or arch (that is, any part of the circumference of a circle) to the other, and is the measure of the arc. Thus the right line *HG* is the measure of the arc *HBG*, fig 8.

18. The segment of a circle is any part thereof which is cut off by a chord: thus the space which is comprehended between the chord *HG* and the arc *HBG*, or that which is compre-

hended between the said chord *HG* and the arc *HDAEG* are called segments. Whence it is plain, fig. 8,

1. That any chord will divide the circle into two segments.

2. The less the chord is, the more unequal are the segments.

3. When the chord is greatest it becomes a diameter, and then the segments are equal; and each segment is a semicircle.*

19. A sector of a circle is a part thereof less than a semicircle, which is contained between two radii and an arc: thus the space contained between the two radii *CH*, *CB*, and the arc *HB* is a sector, fig. 8.

20. The right sine of an arc is a perpendicular line let fall from one end thereof, to a diameter drawn to the other end: thus *HL* is the right sine of the arc *HB*.

The sines on the same diameter increase till they come to the centre, and so become the radius; hence it is plain that the radius *CD* is the greatest possible sine, and thence is called the whole sine.

Since the whole sine *CD* (fig. 8) must be perpendicular to the diameter (by def. 20), therefore producing *DC* to *E*, the two diameters *AB* and *DE* cross one another at right angles, and thus the periphery is divided into four equal parts, as *BD*, *DA*, *AE*, and *EB* (by def. 10); and so *BD* becomes a quadrant, or the fourth part of the periphery; therefore the radius *DC* is always the sine of a quadrant, or of the fourth part of the circle *BD*.

Sines are said to be of as many degrees as the arc contains parts of 360: so the radius being the sine of a quadrant becomes the sine of 90 degrees, or the fourth part of the circle, which is 360 degrees.

21. The versed sine of an arc is that part of the diameter that lies between the right sine and the circumference: thus *LB* is the versed sine of the arc *HB*, fig. 8.

22. The tangent of an arc is a right line touching the periphery, being perpendicular to the end of the diameter, and is terminated by a line drawn from the centre through the other end: thus *BK* is the tangent of the arc *HB*, fig. 8.

23. And the line which terminates the tangent, that is, *CK*, is called the secant of the arc *HB*, fig. 8.

24. What an arc wants of a quadrant is called the complement thereof: thus *DH* is the complement of the arc *HB*, fig. 8.

25. And what an arc wants of a semicircle is called the sup-

* For the demonstration of this consult Prop. 15, Book III. Simpson's Euclid.

plement thereof: thus *AH* is the supplement of the arc *HB*, fig. 8.

26. The sine, tangent, or secant of the complement of any arc is called the co-sine, co-tangent, or co-secant of the arc itself: thus *FH* is the sine, *DI* the tangent, and *CI* the secant of the arc *DH*: or they are the co-sine, co-tangent, or co-secant of the arc *HB*, fig. 8.

27. The sine of the supplement of an arc is the same with the sine of the arc itself; for drawing them according to def. 30, there results the self-same line: thus *HL* is the sine of the arc *HB*, or of its supplement *ADH*, fig. 8.

28. The measure of a right-lined angle is the arc of a circle swept from the angular point, and contained between the two lines that form the angle: thus the angle *HCB*, fig. 8, is measured by the arc *HB*, and is said to contain so many degrees as the arc *HB* does; so if the arc *HB* is 60 degrees, the angle *HCB* is an angle of 60 degrees.

Hence angles are greater or less according as the arc described about the angular point, and terminated by the two sides, contains a greater or less number of degrees of the whole circle.

29. The sine, tangent, and secant of an arc is also the sine, tangent, and secant of an angle whose measure the arc is; thus, because the arc *HB* is the measure of the angle *HCB*, and since *HL* is the sine, *BK* the tangent, and *CK* the secant, *BL* the versed sine, *HF* the co-sine, *DI* the co-tangent, and *CI* the co-secant, &c. of the arc *BH*; then *HL* is called the sine, *BK* the tangent, *CK* the secant, &c. of the angle *HCB*, whose measure is the arc *HB*, fig. 8.

30. Parallel lines are such as are equidistant from each other, as *AB*, *CD*, fig. 9.

31. A figure is a space bounded by a line or lines. If the lines be right it is called a rectilineal figure; if curved it is called a curvilineal figure; but if they be partly right and partly curved lines it is called a mixed figure.

32. The most simple rectilineal figure is a triangle, being composed of three right lines, and is considered in a double capacity: 1st, with respect to its sides; and 2d, to its angles.

33. In respect to its sides, it is either equilateral, having the three sides equal, as *A*, fig. 10.

34. Or isosceles, having two equal sides, as *B*, fig. 11.

35. Or scalene, having the three sides unequal, as *C*, fig. 12.

36. In respect to its angles, it is either right-angled, having one right angle, as *D*, fig. 13,

37. Or obtuse-angled, having one obtuse angle, as *E*, fig. 14

38. Or acute-angled, having all the angles acute, as *F*, fig. 15.

39. Acute and obtuse-angled triangles are in general called oblique-angled triangles, in all which any side may be called the base, and the other two the sides.

40. The perpendicular height of a triangle is a line drawn from the vertex to the base perpendicularly: thus if the triangle *ABC* be proposed, and *BC* be made its base, then if from the vertex *A* the perpendicular *AD* be drawn to *BC*, the line *AD* will be the height of the triangle *ABC*, standing on *BC* as its base, fig. 16.

Hence all triangles between the same parallels have the same height, since all the perpendiculars are equal from the nature of parallels.

41. Any figure of four sides is called a quadrilateral figure.

42. Quadrilateral figures, whose opposite sides are parallel, are called parallelograms: thus *ABCD* is a parallelogram, fig. 3, 17, and *AB*, fig. 18, 19.

43. A parallelogram whose sides are all equal and angles right is called a square, as *ABCD*, fig. 17.

44. A parallelogram whose opposite sides are equal and angles right is called a rectangle, or an oblong, as *ABCD*, fig. 3.

45. A rhombus is a parallelogram of equal sides, and has its angles oblique, as A, fig. 18, and is an inclined square.

46. A rhomboides is a parallelogram whose opposite sides are equal and angles oblique; as B, fig. 19, and may be conceived as an inclined rectangle.

47. Any quadrilateral figure that is not a parallelogram is called a trapezium. Plate 7, fig. 3.

48. Figures which consist of more than four sides are called polygons; if the sides are all equal to each other, they are called regular polygons. They sometimes are named from the number of their sides, as a five-sided figure is called a pentagon, one of six sides a hexagon, &c.; but if their sides are not equal to each other, then they are called irregular polygons, as an irregular pentagon, hexagon, &c.

49. Four quantities are said to be in proportion when the product of the extremes is equal to that of the means: thus if *A* multiplied by *D* be equal to *B* multiplied by *C*, then *A* is said to be to *B* as *C* is to *D*.

POSTULATES, OR PETITIONS.

1. That a right line may be drawn from any one given point to another.

2. That a right line may be produced or continued at pleasure.

3. That from any centre and with any radius the circumference of a circle may be described.

4. It is also required that the equality of lines and angles to others given, be granted as possible: that it is possible for one right line to be perpendicular to another at a given point or distance; and that every magnitude has its half, third, fourth, &c. part.

Note.—Though these postulates are not always quoted, the reader will easily perceive where and in what sense they are to be understood.

AXIOMS, OR SELF-EVIDENT TRUTHS.

1. Things that are equal to one and the same thing are equal to each other.
2. Every whole is greater than its part.
3. Every whole is equal to all its parts taken together.
4. If to equal things equal things be added, the whole will be equal.
5. If from equal things equal things be deducted, the remainders will be equal.
6. If to or from unequal things equal things be added or taken, the sums or remainders will be unequal.
7. All right angles are equal to one another.
8. If two right lines not parallel be produced towards their nearest distance, they will intersect each other.
9. Things which mutually agree with each other are equal.

NOTES.

A theorem is a proposition wherein something is proposed to be demonstrated.

A problem is a proposition wherein something is to be done or effected.

A lemma is some demonstration previous and necessary, to render what follows the more easy.

A corollary is a consequent truth, deduced from a foregoing demonstration.

A scholium is a remark or observation made upon something going before.

GEOMETRICAL THEOREMS.

THEOREM I.

PL. 1. *fig.* 20.

If a right line falls on another, as AB, or EB, does on CD, it either makes with it two right angles, or two angles equal to two right angles.

1. If AB be perpendicular to CD, then (by def. 10) the angles CBA and ABD will be each a right angle.

2. But if the line fall slantwise, as EB, and let AB be perpendicular to CD; then the $\angle DBA=DBE+EBA$: add ABC to each; then, $DBA+ABC=DBE+EBA+ABC$; but $CBE=EBA+ABC$, therefore the angles $DBE+EBC=DBA+ABC$, or two right angles. Q. E. D.

Corollary 1. Whence if any number of right lines were drawn from one point, on the same side of a right line, all the angles made by these lines will be equal to two right angles.

2. And all the angles which can be made about a point will be equal to four right angles.

THEOREM II.

PL. 1. *fig.* 21.

If one right line cross another (as AC does BD), the opposite angles made by those lines will be equal to each other: that is, AEB to CED, and BEC to AED.

By theorem 1, $BEC+CED=$ two right angles.
and $CED+DEA=$ two right angles.

Therefore (by axiom 1) $BEC+CED=CED+DEA$; take CED from both, and there remains $BEC=DEA$ (by axiom 5). Q. E. D.

After the same manner $CED+AED=$ two right angles; and $AED+AEB=$ two right angles; wherefore taking AED from both, there remains $CED=AEB$. Q. E. D.

THEOREM III.

PL. 1. *fig.* 22.

If a right line cross two parallels, as GH does AB and CD, then,

1. Their external angles are equal to each other, that is, GEB=CFH.

2. The alternate angles will be equal, that is, AEF=EFD and BEF=CFE.

3. The external angle will be equal to the internal and opposite one on the same side, that is, GEB=EFD and AEG=CFE.

4. And the sum of the internal angles on the same side are equal to two right angles; that is, BEF+DFE are equal to two right angles, and AEF+CFE are equal to two right angles.

1. Since AB is parallel to CD, they may be considered as one broad line, crossed by another line, as GH; then (by the last theo.) $GEB=CFH$, and $AEG=HFD$.

2. Also $GEB=AEF$, and $CFH=EFD$; but $GEB=CFH$ (by part 1. of this theo.), therefore $AEF=EFD$. The same way we prove $FEB=EFC$.

3. $AEF=EFD$ (by the last part of this theo.); but $AEF=GEB$ (by theo. 2), therefore $GEB=EFD$. The same way we prove $AEG=CFE$.

4. For since $GEB=EFD$, to both add FEB; then (by axiom 4) $GEB+FEB=EFD+FEB$; but $GEB+FEB$ are equal to two right angles (by theo. 1), therefore $EFD+FEB$ are equal to two right angles: after the same manner we prove that $AEF+CFE$ are equal to two right angles. Q. E. D.*

THEOREM IV.

Pl. 1. *fig.* 23.

In any triangle ABC, one of its legs, as BC, being produced towards D, it will make the external angle ACD equal to the two internal opposite angles taken together; viz. to B and A.

Through C, let CE be drawn parallel to AB; then since BD cuts the two parallel lines BA, CE, the angle $ECD=B$ (by part 3 of the last theo.); and again, since AC cuts the same parallels, the angle $ACE=A$ (by part 2 of the last), therefore $ECD+ACE=ACD=B+A$. Q. E. D.

Cor. 1. Hence, if a triangle have its exterior angle and one of its opposite interior angles double of those in another triangle, its remaining opposite interior angle will also be double of the corresponding angle in the other.†

That invaluable instrument, Hadley's Quadrant, is founded on this corollary, annexed as an obvious consequence of the theorem. A ray of light SA (*Pl.* 14. *fig.* 2) from the sun, against the mirror at A, is reflected at an angle equal to its incidence; and now striking the half-silvered glass at C, it is again reflected to E, where the eye likewise receives, through the transparent part of that glass, a direct ray from the boundary of the horizon.

Hence, the triangle AEC has its exterior angle ECD and one of its interior angles CAE respectively double of the exterior angle BCD and the interior angle CAB of the triangle

* For an excellent demonstration of this theorem (by the motion of the straight line crossing the parallel lines about a point in one of them), the reader will consult Leslie's Geometry, Prop. 23, page 26.

† This corollary, with the following demonstration, is found in Leslie's Geometry, pages 32 and 406.

ABC; wherefore the remaining interior angle *AEC*, or *SEZ*, is double of *ABC*; that is, the altitude of the sun above the horizon is double of the inclination of the two mirrors. But the glass at *C* remaining fixed, the mirror at *A* is attached to a moveable index, which marks their inclination.

The same instrument, in its most improved state, and fitted with a telescope, forms the sextant, which, being admirably calculated for measuring angles in general, has rendered the most important services to geography and navigation.

THEOREM V.

PL. 1. *fig.* 23.

In any triangle ABC, all the three angles, taken together, are equal to two right angles, viz. $A+B+ACB=$ *two right angles.*

Produce *CB* to any distance, as *D*, then (by the last) $ACD=B+A$; to both add ACB; then $ACD+ACB=A+B+ACB$; but $ACD+ACB=$ two right angles (by theo. 1); therefore the three angles $A+B+ACB=$ two right angles. Q. E. D.

Cor. 1. Hence if one angle of a triangle be known, the sum of the other two is also known; for since the three angles of every triangle contain two right ones, or 180 degrees, therefore 180— the given angle will be equal to the sum of the other two; or 180— the sum of two given angles gives the other one.

Cor. 2. In every right-angled triangle, the two acute angles are = 90 degrees, or to one right angle; therefore 90— one acute angle gives the other.

THEOREM VI.

PL. 1. *fig.* 24.

If in any two triangles, ABC, DEF, there be two sides AB, AC in the one severally equal to DE, DF in the other, and the angle A contained between the two sides in the one equal to D in the other; then the remaining angles of the one will be severally equal to those of the other, viz. $B=E$, *and* $C=F$; *and the base of the one BC will be equal to EF, that of the other.*

If the triangle *ABC* be supposed to be laid on the triangle *DEF*, so as to make the points *A* and *B* coincide with *D* and *E*, which they will do, because $AB=DE$ (by the hypothesis); and since the angle $A=D$, the line *AC* will fall along *DF*, and inasmuch as they are supposed equal, *C* will fall in *F*; seeing therefore the three points of one coincide with those of the other triangle, they are manifestly equal to each other; therefore the angle $B=E$, and $C=F$, and $BC=EF$. Q. E. D.

LEMMA.

Pl. 1. *fig.* 11.

If two sides of a triangle abc be equal to each other, that is, ac=cb, the angles which are opposite to those equal sides will also be equal to each other; viz. a=b.

For let the triangle *abc* be divided into two triangles *acd*, *dcb*, by making the angle *acd=dcb* (by postulate 4); then because *ac=bc*, and *cd* common (by the last), the triangle *adc=dcb*; and therefore the angle *a=b*. Q. E. D.

Cor. Hence if from any point in a perpendicular which bisects a given line there be drawn right lines to the extremities of the given one, they with it will form an isosceles triangle.

THEOREM VII.

Pl. 1. *fig.* 25.

The angle BCD at the centre of a circle ABED is double the angle BAD at the circumference, standing upon the same arc BED.

Through the point *A*, and the centre *C*, draw the line *ACE*; then the angle *ECD=CAD+CDA* (by theo. 4); but since *AC=CD*, being radii of the same circle, it is plain (by the preceding lemma) that the angles subtended by them will be also equal, and that their sum is double to either of them, that is, *DAC+ADC* is double to *CAD*, and therefore *ECD* is double to *CAD*; after the same manner *BCE* is double to *CAB*, wherefore *BCE+ECD*, or *BCD*, is double to *BAC* +*CAD*, or to *BAD*. Q. E. D.

Cor. 1. Hence an angle at the circumference is measured by half the arc it subtends or stands on.

Fig. 26.

Cor. 2. Hence all angles at the circumference of a circle which stand on the same chord as *AB* are equal to each other, for they are all measured by half the arc they stand on, viz. by half the arc *AB*

Fig. 26.

Cor. 3. Hence an angle in a segment greater than a semicircle is less than a right angle; thus *ADB* is measured by half the arc *AB*; but as the arc *AB* is less than a semicircle, therefore half the arc *AB*, or the angle *ADB*, is less than half a semicircle, and consequently less than a right angle.

Fig. 27.

Cor. 4. An angle in a segment less than a semicircle is greater than a right angle; for since the arc *AEC* is greater than a semicircle, its half, which is the measure of the angle *ABC*,

must be greater than half a semicircle, that is, greater than a right angle.

Fig. 28.

Cor. 5. An angle in a semicircle is a right angle, for the measure of the angle *ABD* is half of a semicircle *AED*, and therefore a right angle.

THEOREM VIII.

PL. 1. *fig.* 29.

If from the centre C of a circle ABE there be let fall the perpendicular CD on the chord AB, it will bisect it in the point D.

Let the lines *AC* and *CB* be drawn from the centre to the extremities of the chord; then since *CA*=*CB*, the angles *CAB* =*CBA* (by the lemma). But the triangles *ADC*, *BDC* are right-angled ones, since the line *CD* is a perpendicular; and so the angle *ACD*=*DCB* (by cor. 2, theo. 5); then have we *AC*, *CD*, and the angle *ACD* in one triangle severally equal to *CB*, *CD*, and the angle *BCD* in the other; therefore (by theo. 6) *AD*=*DB*. Q. E. D.

Cor. Hence it follows, that any line bisecting a chord at right angles is a diameter; for a line drawn from the centre perpendicular to a chord bisects that chord at right angles; therefore, conversely, a line bisecting a chord at right angles must pass through the centre, and consequently be a diameter.

THEOREM IX.

PL. 1. *fig.* 29.

If from the centre of a circle ABE there be drawn a perpendicular CD on the chord AB, and produced till it meets the circle in F, that line CF will bisect the arc AB in the point F.

Let the lines *AF* and *BF* be drawn; then in the triangles *ADF*, *BDF*, *AD*=*BD* (by the last); *DF* is common, and the angle *ADF*=*BDF*, being both right, for *CD* or *DF* is a perpendicular. Therefore (by theo. 6) *AF*=*FB*; but in the same circle, equal lines are chords of equal arcs, since they measure them (by def. 19); whence the arc *AF*=*FB*, and so *AFB* is bisected in *F* by the line *CF*.

Cor. Hence the sine of an arc is half the chord of twice that arc. For *AD* is the sine of the arc *AF* (by def. 20), *AF* is half the arc, and *AD* half the chord *AB* (by theo. 8); therefore the corollary is plain.

THEOREM X.

Pl. 1. *fig.* 30.

In any triangle ABD, the half of each side is the sine of the opposite angle.

Let the circle ADB be drawn through the points A, B, D; then the angle DAB is measured by half the arc BKD (by cor. 1, theo. 7), *viz.* the arc BK is the measure of the angle BAD; therefore (by cor. to the last) BE, the half of BD, is the sine of BAD: in the same way may be proved that half of AD is the sine of ABD, and the half of AB the sine of ADB. Q. E. D.

THEOREM XI.

Pl. 1. *fig.* 22.

If a right line GH cut two other right lines AB, CD, so as to make the alternate angles AEF, EFD equal to each other, then the lines AB and CD will be parallel.

If it be denied that AB is parallel to CD, let IK be parallel to it; then $IEF=(EFD)=AEF$ (by part 2, theo. 3), a greater to a less, which is absurd, whence IK is not parallel; and the like we can prove of all other lines but AB; therefore AB is parallel to CD. Q. E. D.

THEOREM XII.

Pl. 1. *fig.* 3.

If two equal and parallel lines AB, CD, be joined by two other lines AD, BC, those shall be also equal and parallel.

Let the diameter or diagonal BD be drawn, and we will have the triangles ABD, CBD, whereof AB in one is $=$ to CD in the other, BD common to both, and the angle $ABD=CDB$ (by part 2, theo. 3); therefore (by theo. 6) $AD=CB$, and the angle $CBD=ADB$; and thence the lines AD and BC are parallel, by the preceding theorem.

Cor. 1. Hence the quadrilateral figure $ABCD$ is a parallelogram, and the diagonal BD bisects the same, inasmuch as the triangle $ABD=BCD$, as now proved.

Cor. 2. Hence also the triangle ABD on the same base AB, and between the same parallels with the parallelogram $ABCD$, is half the parallelogram.

Cor. 3. It is hence also plain that the opposite sides of a parallelogram are equal; for it has been proved that, $ABCD$ being a parallelogram, AB will be $=CD$, and $AD=BC$.

THEOREM XIII.

Pl. 1. *fig.* 31

All parallelograms on the same or equal bases and between the same parallels are equal to one another; that is, if $BD=GH$, and the lines BH and AF are parallel, then the parallelogram $ABDC=BDFE=EFHG$.

For $AC=BD=EF$ (by cor. the last); to both add CE, then $AE=CF$. In the triangles ABE, CDF, $AB=CD$ and $AE=CF$, and the angle $BAE=DCF$ (by part 3, theo. 3); therefore the triangle $ABE=CDF$ (by theo. 6); let the triangle CKE be taken from both, and we will have the trapezium $ABKC=KDFE$: to each of these add the triangle BKD, then the parallelogram $ABCD=BDEF$: in like manner we may prove the parallelogram $EFGH=BDEF$. Wherefore $ABDC=BDEF=EFGH$. Q. E. D.

Cor. Hence it is plain that triangles on the same or equal bases and between the same parallels are equal, seeing (by cor. 2, theo. 12) they are the halves of their respective parallelogram.

THEOREM XIV.

Pl. 1. *fig.* 32.

In every right-angled triangle, ABC, the square of the hypothenuse or longest side, BC, or $BCMH$, is equal to the sum of the squares made on the other two sides AB and AC, that is, $ABDE$ and $ACGF$.

Through A draw AKL perpendicular to the hypothenuse BC, join AH, AM, DC, and BG; in the triangles BDC, ABH, $BD=BA$, being sides of the same square, and also $BC=BH$, and the included angles $DBC=ABH$ (for $DBA=CBH$ being both right, to both add ABC, then $DBC=ABH$), therefore the triangle $DBC=ABH$ (by theo. 6); but the triangle DBC is half of the square $ABDE$ (by cor. 2, theo. 12), and the triangle ABH is half the parallelogram $BKLH$. The same way it may be proved that the square $ACGF$ is equal to the parallelogram $KCLM$. So $ABDE+ACGF$ the sum of the squares $=BKLH+KCML$, the sum of the two parallelograms or square $BCMH$; therefore the sum of the squares on AB and AC is equal to the square on BC. Q. E. D.*

Cor. 1. Hence the hypothenuse of a right-angled triangle may be found by having the sides: thus, the square root of the sum of the squares of the base and perpendicular will be the hypothenuse.

* For different demonstrations of this excellent theorem, the reader may consult Leslie's Geometry (Prop. xi. book ii.).

Cor. 2. Having the hypothenuse and one side given to find the other; the square root of the difference of the squares of the hypothenuse and given side will be the required side.

THEOREM XV.

Pl. 1. *fig.* 33.

In all circles the chord of 60 degrees is always equal in length to the radius.

Thus in the circle AEBD, if the arc AEB be an arc of 60 degrees, and the chord AB be drawn, then $AB=CB=AC$.

In the triangle ABC the angle ACB is 60 degrees, being measured by the arc AEB; therefore the sum of the other two angles is 120 degrees (by cor. 1, theo. 5); but since $AC=CB$, the angle $CAB=CBA$ (by lemma preceding theo. 7); consequently each of them will be 60, the half of 120 degrees, and the three angles will be equal to one another as well as the three sides: wherefore $AB=BC=AC$. Q. E. D.

Cor. Hence the radius from whence the lines on any scale are formed is the chord of 60 degrees on the line of chords.

THEOREM XVI.

Pl. 1. *fig.* 34.

If in two triangles, ABC, abc, all the angles of one be each respectively equal to all the angles of the other; that is, $A=a$, $B=b$, $C=c$; *then the sides opposite to the equal angles will be proportional, viz.*

$$AB : ab :: AC : ac$$
$$AB : ab :: BC : bc$$
$$\text{and } AC : ac :: BC : bc$$

For the triangles being inscribed in two circles, it is plain, since the angle $A=a$, the arc $BDC=$* bdc and consequently the chord BC is to bc as the radius of the circle ABC is to the radius of the circle abc (for the greater the radius is, the greater is the circle described by that radius; and consequently the greater any particular arc of that circle is, so the chord, sine, tangent, &c. of that arc will be also greater. Therefore, in general, the chord, sine, tangent, &c. of any arc is proportional to the radius of the circle); the same way the chord AB is to the chord ab in the same proportion. So $AB : ab :: BC : bc$. The same way the rest may be proved to be proportional.

* The arc BDC is not = in length to bdc, as might be supposed from the sign of equality; but they contain the same number of degrees, as being the measure of equal angles.

THEOREM XVII.

Pl. 1. *fig.* 35.

If from a point A without a circle DBCE there be drawn two lines ADE, ABC, each of them cutting the circle in two points, the product of one whole line into its external part, viz. AC into AB, will be equal to that of the other line into its external part, viz. AE into AD.

Let the lines DC, BE be drawn into two triangles ABE, ADC; the angle $AEB=ACD$ (by cor. 2, theo. 7); the angle A is common, and (by cor. 1, theo. 5) the angle $ADC=ABE$; therefore the triangles ABE, ADC are mutually equiangular, and consequently (by the last) $AC : AE :: AD : AB$; wherefore AC multiplied by AB will be equal to AE multiplied by AD. Q. E. D.

THEOREM XVIII.

Pl. 2. *fig.* 1.

Triangles ABC, BCD, and parallelograms ABCF and BDEC, having the same altitude, have the same proportion between themselves as their bases BA and BD.

Let any aliquot part of AB be taken which will also measure BD: suppose that to be Ag, which will be contained twice in AB, and three times in BD, the parts Ag, gB, Bh, hi, and iD being all equal, and let the lines gC, hC, and iC be drawn: then (by cor. to theo. 13) all the small triangles AgC, gCB, BCh, &c. will be equal to each other, and will be as many as the parts into which their bases were divided; therefore it will be, as the sum of the parts in one base is to the sum of those in the other, so will be the sum of the small triangles in the first to the sum of the small triangles in the second triangle; that is, $AB : BD :: ABC : BDC$.

Whence also the parallelograms $ABCF$ and $BDEC$, being (by cor. 2, theo. 12) the doubles of the triangles, are likewise as their bases. Q. E. D.

Note.—Wherever there are several quantities connected with the sign (: :) the conclusion is always drawn from the first two and last two proportionals.

THEOREM XIX.

Pl. 2. *fig.* 2.

Triangles ABC, DEF, standing upon equal bases AB and DE, are to each other as their altitudes CG and FH.

Let BI be perpendicular to AB and equal to CG, in which let $KB=FH$, and let AI and AK be drawn.

The triangle $AIB=ACB$ (by cor. to theo. 13), and $AKB=DEF$; but (by theo. 18) $BI : BK :: ABI : ABK$. That is, $CG : FH :: ABC : DEF$. Q. E. D.

THEOREM XX.

PL. 2. *fig*. 3.

If a right line BE be drawn parallel to one side of a triangle ACD, it will cut the two other sides proportionally, viz. $AB : BC :: AE : ED$.

Draw CE and BD; the triangles BEC and EBD being on the same base BE and under the same parallel CD, will be equal (by cor. to theo. 13) therefore (by theo. 18) $AB : BC ::$ ($BEA : BEC$ or $BEA : BED ::$) $AE : ED$. Q. E. D.

Cor. 1. Hence also $AC : AB :: AD : AE$; for $AC : AB$ ($AEC : AEB :: ABD : AEB$) $:: AD : AE$.

Cor. 2. It also appears that a right line which divides two sides of a triangle proportionally must be parallel to the remaining side.

Cor. 3. Hence, also, theo. 16 is manifest; since the sides of the triangles ABE, ACD, being equiangular, are proportional.

THEOREM XXI.

PL. 2. *fig*. 4.

If two triangles ABC, ADE have an angle BAC in the one equal to an angle DAE in the other, and the sides about the equal angles proportional; that is, $AB : AD :: AC : AE$; *then the triangles will be mutually equiangular.*

In AB take $Ad=AD$, and let de be parallel to BC, meeting AC in e.

Because (by the first cor. to the foregoing theo.) $AB : Ad$ (or AD) $:: AC : Ae$, and (by the hypothesis, or what is given in the theorem) $AB : AD :: AC : AE$; therefore $Ae=AE$, seeing AC bears the same proportion to each; and (by theo. 6) the triangle $Ade=ADE$, therefore the angle $Ade=D$ and $Aed=E$; but since ed and BC are parallel (by part 3, theo. 3) $Ade=B$, and $Aed=C$, therefore $B=D$ and $C=E$. Q. E. D.

THEOREM XXII.

PL. 2. *fig*. 5.

Equiangular triangles ABC, DEF are to one another in a duplicate proportion of their homologous or like sides; or as the squares AK and DM of their homologous sides.

Let the perpendiculars CG and FH be drawn, as well as the diagonals BI and EL.

The perpendiculars make the triangles ACG and DFH equiangular, and therefore similar (by theo. 16); for because the angle $CAG=FDH$, and the right angle $AGC=DHF$, the remaining angle $ACG=DFH$ (by cor. 2. theo. 5).

Therefore $GC : FH :: (AC : DF ::)\ AB : DE$, or, which is the same thing, $GC : AB :: FH : DE$, for FH multiplied by $AB=GC$ multiplied by DE.

By theo. 19, $ABC : ABI :: (CG : AI$ or AB as before $:: FH : DE$, or $DL) :: DFE : DLE$, therefore $ABC : ABI :: DFE : DLE$, or $ABC : AK :: DFE : DM$, for AK is double the triangle ABI, and DM double the triangle DEL, (by cor. 2 theo. 12.) Q. E. D.

THEOREM XXIII.

PL. 2. *fig.* 6.

Like polygons ABCDE, abcde are in a duplicate proportion to that of the sides AB, ab, which are between equal angles A and B and a and b, or as the squares of the sides AB, ab.

Draw AD, AC, ad, ac.

By the hypothesis $AB : ab :: BC : bc$, and thereby also the angle $B=b$; therefore (by theo. 21) $BAC=bac$; and $ACB=acb$: in like manner $EAD=ead$, and $EDA=eda$. If therefore from the equal angles A and a, we take the equal ones $EAD+BAC=ead+bac$, the remaining angle $DAC=dac$, and if from the equal angles D and d, $EDA=eda$ be taken, we shall have $ADC=adc$: and in like manner if from C and c be taken $BCA=bca$, we shall have $ACD=acd$; and so the respective angles in every triangle will be equal to those in the other.

By theo. 22, $ABC : abc ::$ the square of AC to the square of ac, and also $ADC : adc ::$ the square of AC to the square of ac; therefore, from equality of proportions, $ABC : abc :: ADC : adc$; in like manner we may show that $ADC : adc :: EAD : ead$. Therefore it will be, as one antecedent is to one consequent, so are all the antecedents to all the consequents. That is, ABC is to abc as the sum of the three triangles in the first polygon is to the sum of those in the last. Or ABC will be to abc as polygon to polygon.

The proportion of ABC to abc (by the foregoing theo.) is as the square of AB is to the square of ab, but the proportion of polygon to polygon is as ABC to abc, as now shown: therefore the proportion of polygon to polygon is as the square of AB to the square of ab.

THEOREM XXIV.

Pl. 1. fig. 8.

Let DHB be a quadrant of a circle described by the radius CB; HB an arc of it, and DH its complement; HL or FC the sine, FH or CL its cosine, BK its tangent, DI its cotangent; CK its secant, and CI its cosecant. Fig. 8.

1. The cosine of an arc is to the sine as the radius is to the tangent.

2. The radius is to the tangent of an arc as the cosine of it is to the sine.

3. The sine of an arc is to its cosine as the radius to its cotangent.

4. Or the radius is to the cotangent of an arc as its sine to its co-sine.

5. The cotangent of an arc is to the radius as the radius to the tangent.

6. The cosine of an arc is to the radius as the radius is to the secant.

7. The sine of an arc is to the radius as the tangent is to the secant.

The triangles *CLH* and *CBK* being similar (by theo. 16),

1. $CL : LH :: CB : BK$.

2. Or, $CB : BK :: CL : LH$.

The triangles *CFH* and *CDI* being similar,

3. CF (or LH) $: FH :: CD : DI$.

4. $CD : DI :: CF$ (or LH) $: FH$.

The triangles *CDI* and *CBK* are similar; for the angle $CID = KCB$, being alternate ones (by part 2, theo. 3), the lines *CB* and *DI* being parallel, the angle $CDI = CBK$ being both right, and consequently the angle $DCI = CKB$, wherefore,

5. $DI : CD :: CB : BK$.

And again, making use of the similar triangle *CLH* and *CBK*,

6. $CL : CB :: CH : CK$.

7. $HL : CH :: BK : CK$.

GEOMETRICAL PROBLEMS.

PROBLEM I.

PL. 2. *fig.* 7.

To make a triangle of three given right lines BO, LB, LO, of which any two must be greater than the third.

Lay *BL* from *B* to *L*; from *B* with the line *BO* describe an arc, and from *L* with *LO* describe another arc; from *O*, the intersecting point of those arcs, draw *BO* and *OL*, and *BOL* is the triangle required.

This is manifest from the construction.

PROBLEM II.

PL. 2. *fig.* 8.

At a point B in a given right line BC, to make an angle equal to a given angle A.

Draw any right line *ED* to form a triangle, as *EAD*, take $BF = AD$, and upon *BF* make the triangle *BFG*, whose side $BG = AE$, and $GF = ED$ (by the last), then also the angle $B = A$; if we suppose one triangle be laid on the other, the sides will mutually agree with each other, and therefore be equal; for if we consider these two triangles to be made of the same three given lines, they are manifestly one and the same triangle.

Otherwise,

Upon the centres *A* and *B*, at any distance, let two arcs *DE*, *FG*, be described; make the arc $FG = DE$, and through *B* and *G* draw the line *BG*, and it is done.

For since the chords *ED*, *GF* are equal, the angles *A* and *B* are also equal, as before (by def. 17).

PROBLEM III.

PL. 2. *fig.* 9.

To bisect or divide into two equal parts any given right-lined angle BAC.

In the lines *AB* and *AC*, from the point *A*, set off equal distances $AE = AD$; then, with any distance more than the half of *DE*, describe two arcs to cut each other in some point *F*; and the right line *AF*, joining the points *A* and *F*, will bisect the given angle *BAC*.

For if *DF* and *FE* be drawn, the triangles *ADF*, *AEF* are equilateral to each other, viz. $AD = AE$, $DF = FE$, and *AF* common, wherefore $DAF = EAF$, as before.

PROBLEM IV.

PL. 2. *fig.* 10.

To bisect a right line AB.

With any distance more than half the line from *A* and *B*, describe two circles *CFD*, *CGD*, cutting each other in the points *C* and *D*; draw *CD* intersecting *AB* in *E*, then *AE*=*EB*.

For, if *AC*, *AD*, *BC*, *BD* be drawn, the triangles *ACD*, *BCD* will be mutually equilateral, and consequently the angle *ACE*=*BCE*; therefore the triangle *ACE*, *BCE*, having *AC*=*BC*, *CE* common, and the angle *ACE*=*BCE*; (by theo. 6) the base *AE*=the base *BE*.

Cor. Hence it is manifest that *CD* not only bisects *AB*, but is perpendicular to it (by def. 10).

PROBLEM V.

PL. 2. *fig.* 11.

On a given point A, in a right line EF, to erect a perpendicular.

From the point *A* lay off on each side the equal distances *AC*, *AD*; and from *C* and *D* as centres, with any interval greater than *AC* or *AD*, describe two arcs intersecting each other in *B*; from *A* to *B* draw the line *AB*, and it will be the perpendicular required.

For let *CB* and *BD* be drawn, then the triangles *CAB*, *DAB* will be mutually equilateral and equiangular, so *CAB*=*DAB*, a right angle (by def. 10).

PROBLEM VI.

PL. 2. *fig.* 12.

To raise a perpendicular on the end B of a right line AB.

From any point *D* not in the line *AB*, with the distance from *D* to *B*, let a circle be described cutting *AB* in *E*; draw from *E* through *D* the right line *EDC*, cutting the periphery in *C*, and join *CB*, and that is the perpendicular required.

EBC being a semicircle, the angle *EBC* will be a right angle (by cor. 5, theo. 7).

PROBLEM VII.

PL. 2. *fig.* 13.

From a given point A, to let fall a perpendicular upon a given right line BC.

From any point *D*, in the given line, take the distance to the given point *A*, and with it describe a circle *AGE* make *GE*=

AG, join the points A and E by the line AFE, and AF will be the perpendicular required.

Let DA, DE be drawn, the angle $ADF=FDE$, $DA=DE$, being radii of the same circle, and DF common; therefore (by theo. 6) the angle $DFA=DFE$, and FA a perpendicular. (By def. 10.)

PROBLEM VIII.

PL. 2. *fig.* 14.

Through a given point A to draw a right line AB, parallel to a given right line CD.

From the point A to any point F in the line CD draw the line AF; with the interval FA, and one foot of the compasses in F, describe the arc AE, and with the like interval and one foot in A describe the arc BF, making $BF=AE$; through A and B draw the line AB, and it will be parallel to CD.

By prob. 2, The angle $BAF=AFE$, and by theo. 11, BA and CD are parallel.

PROBLEM IX.

PL. 1. *fig.* 17.

Upon a given line AB to describe a square ABCD.

Make BC perpendicular and equal to AB, and from A and C, with the line AB or BC, let two arcs be described, cutting each other in D; from whence to A and C let the lines AD, DC be drawn; so is $ABCD$ the square required.

For all the sides are equal by construction; therefore the triangles ADC and BAC are mutually equilateral and equiangular, and $ABCD$ is an equilateral parallelogram, whose angles are right. For B being right, D is also right, and DAC, DCA, BAC, ACB, each half a right angle (by lemma preceding theo. 7, and cor. 2, theo. 5), whence DAB and BCD will each be a right angle, and (by def. 43) $ABCD$ is a square.

SCHOLIUM.

By the same method a rectangle or oblong may be described, the sides thereof being given.

PROBLEM X.

PL. 2. *fig.* 15.

To divide a given right line AB into any proposed number of equal parts.

Draw the indefinite right line AP, making any angle with

AB, also draw *BQ* parallel to *AP*, in each of which let there be taken as many equal parts *AM*, *MN*, &c. *Bo*, *on*, &c. as you would have *AB* divided into; then draw *Mm*, *Nn*, &c. intersecting *AB* in *E*, *F*, &c. and it is done.

For *MN* and *mn* being equal and parallel, *FN* will be parallel to *EM*, and in the same manner *GO* to *FN* (by theo. 12); therefore *AM*, *MN*, *NO*, being all equal by construction, it is plain (from theo. 20) that *AE*, *EF*, *FG*, &c. will likewise be equal.

PROBLEM XI.

PL. 2. *fig.* 16.

To find a third proportional to two given right lines A and B.

Draw two indefinite blank lines *CE*, *CD* anywise to make any angle. Lay the line *A* from *C* to *F*, and the line *B* from *C* to *G*, and draw the line *FG*; lay again the line *A* from *C* to *H*, and through *H* draw *HI* parallel to *FG* (by prob. 8), so is *CI* the third proportional required.

For, by cor. 1, theo. 20, $CG : CH :: CF : CI$.

Or, $B : A :: A : CI$.

PROBLEM XII.

PL. 2. *fig.* 17.

Three right lines A, B, C given, to find a fourth proportional.

Having made an angle *DEF* anywise, by two indefinite blank right lines *ED*, *EF*, as before; lay the line *A* from *E* to *G*, the line *B* from *E* to *I*, and draw the line *IG*; lay the line *C* from *E* to *H*, and (by prob. 8) draw *HK* parallel thereto, so will *EK* be the fourth proportional required.

For, by cor. 1, theo. 20, $EG : EI :: EH : EK$.

Or, $A : B :: C : EK$.

PROBLEM XIII.

PL. 3. *fig.* 1.

Two right lines A and B given, to find a mean proportional.

Draw an indefinite straight line, on which place $AB=A$ and $BC=B$; bisect *AC* (by prob. 4) in *E*, and describe the semicircle *ADC*, and from the point *B* erect the perpendicular *BD* (by prob. 5), then *BD* is a mean proportional.

For if the lines *AD*, *DC* be drawn, the angle *ADC* is a right angle (by cor. 5, theo. 7), being an angle in a semicircle.

The angles *ABD*, *DBC* are right ones (by def. 10), the line *BD* being a perpendicular; wherefore the triangles *ABD*,

DBC are similar: thus the angle *ABD*=*DBC*, being both right, the angle *DAC* is the complement of *BDA* to a right angle (by cor. 2, theo. 5), and is therefore equal to *BDC*, the angle *ADC* being a right angle as before; consequently (by cor. 1, theo. 5) the angle *ADB*=*DCB*; wherefore (by theo. 16),

$AB : BD :: BD : BC$

Or, $A : BD :: BD : B$.

PROBLEM XIV.

PL. 3. *fig.* 2.

To divide a right line AB in the point E, so that AE shall have the same proportion to EB as two given lines C and D have.

Draw an indefinite blank line *AF* to the extremity of the line *AB*, to make with it any angle; lay the line *C* from *A* to *C*, and *D* from *C* to *D*, and join the points *B* and *D* by the line *BD*; through *C* draw *CE* parallel to *BD* (by prob. 8), so is *E* the point of division.

For, by theo. 20, $AC : CD :: AE : EB$.

Or, $C : D :: AE :: EB$.

PROBLEM XV.

PL. 3. *fig.* 3.

To describe a circle about a triangle ABC, or (which is the same thing) through any three points A, B, C, which are not situated in a right line.

By prob. 4. Bisect the line *AC* by the perpendicular *DE*, and also *CB* by the perpendicular *FG*, the point of intersection *H* of these perpendiculars is the centre of the circle required; from which take the distance to any of the three points *A*, *B*, *C*, and describe the circle *ABC*, and it is done.

For, by cor. to theo. 8, the lines *DE* and *FG* must each pass through the centre; therefore their point of intersection *H* must be the centre.

SCHOLIUM.

By this method the centre of a circle may be found, by having only a segment of it given.

PROBLEM XVI.

PL. 3. *fig.* 4.

To make an angle of any number of degrees at the point A of the line AB, suppose of 45 degrees.

From a scale of chords take 60 degrees, for 60° is equal to the radius (by cor. theo. 15), and with that distance from *A* as a centre, describe a circle from the line *AB*; take 45 degrees,

the quantity of the given angle, from the same scale of chords, and lay it on that circle from a to b; through A and b draw the line AbC, and the angle A will be an angle of 45 degrees, as required.

If the given angle be more than 90°, take its half (or divide it into any two parts less than 90 and lay them after each other on the arc, which is described with the chord of 60 degrees; through the extremity of which and the centre, let a line be drawn, and that will form the angle required, with the given line.

PROBLEM XVII.

PL. 3. *fig.* 5.

To measure a given angle ABC.

If the lines which include the angle be not as long as the chord of 60° on your scale, produce them to that or a greater length, and between them so produced, with the chord of 60° from B, describe the arc cd; which distance ed, measured on the same line of chords, gives the quantity of the angle ABC, as required; this is plain from def. 17.

PROBLEM XVIII.

PL. 3. *fig.* 6.

To make a triangle BCE equal to a given quadrilateral figure ABCD.

Draw the diagonal AC, and parallel to it (by prob. 8) DE, meeting AB produced in E; then draw CE, and ECB will be the triangle required.

For the triangles ADC, AEC being upon the same base AC, and under the same parallel ED (by cor. to theo. 13), will be equal, therefore if ABC be added to each, then $ABCD = BEC$.

PROBLEM XIX.

PL. 3. *fig.* 7.

To make a triangle DFH equal to a given five-sided figure ABCDE.

Draw DA and DB, and also EH and CF parallel to them, (by prob. 8) meeting AB produced in H and F; then draw DH, DF, and the triangle HDF is the one required.

For the triangle $DEA = DHA$, and $DBC = DFB$ (by cor. to theo. 13); therefore by adding these equations, $DEA + DBC = DHA + DFB$, if to each of these ADB be added; then $DEA + ADB + DBC = ABCDE$ $(= DHA + ABD + DFB) = DHF$.

PROBLEM XX.

PL. 2. *fig.* 8.

To project the lines of chords, sines, tangents, and secants with any radius.

On the line *AB*, let a semicircle *ADB* be described; let *CDF* be drawn perpendicular to this line from the centre *C*; and the tangent *BE* perpendicular to the end of the diameter; let the quadrants *AD*, *DB* be each divided into nine equal parts, every one of which will be ten degrees; if then from the centre *C* lines be drawn through 10, 20, 30, 40, &c. the divisions of the quadrant *BD*, and continued to *BE*, we shall there have the tangents of 10, 20, 30, 40, &c. and the secants *C* 10, *C* 20, *C* 30, &c. are transferred to the line *CF*, by describing the arcs 10, 10; 20, 20; 30, 30, &c. If from 10, 20, 30, &c. the divisions of the quadrant *BD*, there be let fall perpendiculars, let these be transferred to the radius *CB*, and we shall have the sines of 10, 20 30, &c. and if from *A* we describe the arcs 10, 10; 20, 20; 30, 30, &c. from every division of the arc *AD*, we shall have a line of chords. The same way we may have the sine, tangent, &c. to every single degree on the quadrant, by subdividing each of the nine former divisions into ten equal parts. By this method the sines, tangents, &c. may be drawn to any radius; and then, after they are transferred to lines on a rule, we shall have the scales of sines, tangents, &c. ready for use.

MATHEMATICAL

DRAWING INSTRUMENTS.

THE strictness of geometrical demonstration admits of no other instruments than a rule and a pair of compasses. But, in proportion as the practice of geometry was extended to the different arts, either connected with or dependent upon it, new instruments became necessary, some to answer peculiar purposes, some to facilitate operation, and others to promote accuracy.

As almost every artist whose operations are connected with mathematical designing furnishes himself with a case of drawing instruments suited to his peculiar purposes, they are fitted up in various modes, some containing more, others fewer instruments. The smallest collection put into a case consists of a plane scale, a pair of compasses with a moveable leg, and two spare points, which may be applied occasionally to the

compasses; one of these points is to hold ink; the other a portcrayon, for holding a piece of black-lead pencil.

What is called a full pocket case, contains the following instruments.

A pair of large compasses with a moveable point, an ink point, a pencil point, and one for dotting; either of those points may be inserted in the compasses instead of the moveable leg.

A pair of plain compasses somewhat smaller than those with the moveable leg.

A pair of bow compasses.

A drawing pen with a protracting pin in the upper part.

A sector.

A plain scale.

A protractor.

A parallel rule.

A pencil and screwdriver.*

* Large collections are called *magazine cases of instruments*; these generally contain—

A pair of six inch compasses with a moveable leg, an ink point, a dotting point, the crayon point, so contrived as to hold a whole pencil, two additional pieces to lengthen occasionally one leg of the compasses, and thereby enable them to measure greater extents, and describe circles of a larger radius.

A pair of hair compasses.

A pair of bow compasses.

A pair of triangular compasses.

A sector.

A parallel rule.

A protractor.

A pair of proportional compasses, either with or without an adjusting screw.

A pair of wholes and halves.

Two drawing pens, and a pointril.

A pair of small hair compasses, with a head similar to those of the bow compasses.

A knife, a file, a key, and screwdriver, or the compasses in one piece.

A small set of fine water-colours.

To these some of the following instruments are often added:—

A pair of beam compasses.

A pair of gunners' callipers.

A pair of elliptical compasses.

A pair of spiral compasses.

A pair of perspective compasses.

A pair of compasses with a micrometer screw.

A rule for drawing lines, tending to a centre at a great distance.

A protractor and parallel rule.

One or more parallel rules.

A pantographer, or pentagraph.

A pair of sectoral compasses, forming at the same time a pair of beam and calliper compasses.

In a case with the best instruments, the protractor and plain scale are always combined. The instruments in most general use are those of six inches; instruments are seldom made longer, but often smaller. Those of six inches are, however, to be preferred, in general, before any other size; they will effect all that can be performed with the shortest ones, while at the same time, they are better adapted to large works.

OF DRAWING COMPASSES.

Compasses are made either of silver or brass, but with steel points. The joints should always be framed of different substances; thus, one side or part should be of silver or brass, and the other of steel. The difference in the texture and pores of the two metals causes the parts to adhere less together, diminishes the wear, and promotes uniformity in their motion. The truth of the work is ascertained by the smoothness and equality of the motion at the joint, for all shake and irregularity is a certain sign of imperfection. The points should be of steel, so tempered as neither to be easily bent or blunted; not too fine and tapering, and yet meeting closely when the compasses are shut.

As an instrument of art, compasses are so well known that it would be superfluous to enumerate their various uses; suffice it then to say, that they are used to transfer small distances, measure given spaces, and describe arches and circles.

If an arch or circle is to be described obscurely, the steel points are best adapted to the purpose; if it is to be in ink or black lead, either the drawing pen, or crayon points are to be used.

To use a pair of compasses. Place the thumb and middle finger of the right hand in the opposite hollows in the shanks of the compasses, then press the compasses, and the legs will open a little way; this being done, push the innermost leg with the third finger, elevating at the same time the furthermost with the nail of the middle finger, till the compasses are sufficiently opened to receive the middle and third finger; they may then be extended at pleasure, by pushing the furthermost leg outwards with the middle, or pressing it inwards with the forefinger. In describing circles or arches, set one foot of the compasses on the centre, and then roll the head of the compasses between the middle and fore-finger, the other point pressing at the same time upon the paper. They should be held as upright as possible, and care should be taken not to press forcibly upon them, but rather to let them act by their

own weight; the legs should never be so far extended as to form an obtuse angle with the paper or plane on which they are used.

The ink and crayon points have a joint just under that part which fits into the compasses; by this they may be always so placed as to be set nearly perpendicular to the paper; the end of the shank of the best compasses is framed so as to form a strong spring, to bind firmly the moveable points, and prevent them from shaking. This is found to be a more effectual method than that by a screw.

Two additional pieces are often applied to these compasses; these, by lengthening the leg, enable them to strike larger circles, or measure greater extents, than they would otherwise perform, and that without the inconveniences attending longer compasses. When compasses are furnished with this additional piece, the moveable leg has a joint, that it may be placed perpendicular to the paper.

The bow compasses are a small pair, usually with a point for ink; they are used to describe small arches or circles, which they do much more conveniently than large compasses, not only on account of their size, but also from the shape of the head, which rolls with great ease between the fingers.

Of the drawing pen and protracting pin. The pen part of this instrument is used to draw straight lines: it consists of two blades with steel points fixed to a handle; the blades are so bent that the ends of the steel points meet, and yet leave a sufficient cavity for the ink; the blades may be opened more or less by a screw, and, being properly set, will draw a line of any assigned thickness. One of the blades is framed with a joint, that the points may be separated and thus cleaned more conveniently. A small quantity only of ink should be put at one time into the drawing pen, and this should be placed in the cavity between the blades by a common pen or feeder; the drawing pen acts better if the pen by which the ink is inserted be made to pass through the blades. To use the drawing pen, first feed it with ink, then regulate it to the thickness of the required line by the screw. In drawing lines, incline the pen a small degree, taking care, however, that the edges of both the blades touch the paper, keeping the pen close to the rule, and in the same direction during the whole operation. The blades should always be wiped very clean before the pen is put away.

These directions are equally applicable to the ink point of the compasses, only observing, that when an arch or circle

is to be described of more than an inch radius, the point should be so bent that the blades of the pen may be nearly perpendicular to the paper, and both of them touch it at the same time.

The protracting pin is only a short piece of steel wire with a very fine point fixed at one end of the upper part of the handle of the drawing pen. It is used to mark the intersection of lines, or to set off divisions from the plotting scale and protractor.

OF THE SECTOR.

Amid the variety of mathematical instruments that have been contrived to facilitate the art of drawing, there is none so extensive in its use or of such general application as the *sector*. It is a universal scale, uniting, as it were, angles and parallel lines, the rule and the compass, which are the only means that geometry makes use of for measuring, whether in speculation or practice. The real inventor of this valuable instrument is unknown; yet of so much merit has the invention appeared, that it was claimed by *Galileo*, and disputed by nations.

This instrument derives its name from the tenth definition of the third book of *Euclid*, where he defines the sector of a circle. It is formed of two equal rules called legs; these legs are moveable about the centre of a joint, and will, consequently, by their different openings, represent every possible variety of plane angles. The distance of the extremities of these rules are the subtenses or chords, or the arches they describe.

Sectors are made of different sizes, but their length is usually denominated from the length of the legs when the sector is shut. Thus a sector of six inches when the legs are close together forms a rule of twelve inches when opened; and a foot sector is two feet long when opened to its greatest extent. In describing the lines usually placed on this instrument, I refer to those commonly laid down on the best six-inch brass sectors. But as the principles are the same in all, and the differences little more than in the number of subdivisions, it is to be presumed that no difficulty will occur in the application of what is here said to sectors of a larger radius.

The scales, or lines graduated upon the faces of the instrument, and which are to be used as *sectoral lines*, proceed from the centre, and are, 1. Two scales of equal parts, one on each leg, marked LIN. or L. Each of these scales, from the great extensiveness of its use, is called the *line of lines*. 2. Two lines of *chords*, marked CHO. or C. 3. Two lines of *secants*,

marked SEC. or S. A line of *polygons*, marked POL. Upon the other face the sectoral lines are, 1. Two lines of *sines* marked SIN. or S. 2. Two lines of *tangents*, marked TAN. 3. Between the lines of tangents and sines there is another line of tangents to a lesser radius, to supply the defect of the former, and extending from 45° to 75°.

Each pair of these lines, except the line of polygons, is so adjusted as to make equal angles at the centre, and consequently at whatever distance the sector be opened, the angles will be always respectively equal. That is, the distance between 10 and 10 on the line of lines will be equal to 60 and 60 on the line of chords, 90 and 90 on the line of sines, and 45 and 45 on the line of tangents.

Besides the sectoral scales, there are others on each face placed parallel to the outward edges, and used as those of the common plain scale. There are on the one face, 1. A line of inches. 2. A line of latitudes. 3. A line of hours. 4. A line of inclination of meridians. 5. A line of chords. On the other face, three logarithmic scales, namely, one of numbers, one of sines, and one of tangents: these are used when the sector is fully opened, the legs forming one line.

To read and estimate the divisions on the sectoral lines. The value of the divisions on most of the lines is determined by the figures adjacent to them; these proceed by tens, which constitute the divisions of the first order, and are numbered accordingly; but the value of the divisions on the line of lines, that are distinguished by figures, is entirely arbitrary, and may represent any value that is given to them; hence the figures 1, 2, 3, 4, &c. may denote either 10, 20, 30, 40, or 100, 200, 300, 400, and so on.

The line of lines is divided into ten equal parts, numbered 1, 2, 3, to 10; these may be called divisions of the first order; each of these is again subdivided into 10 other equal parts, which may be called divisions of the second order; and each of these is divided into two equal parts, forming divisions of the third order.

The divisions on all the scales are contained between four parallel lines: those of the first order extend to the most distant, those of the third to the least, those of the second to the intermediate parallel.

When the whole line of lines represents 100, the divisions of the first order, or those to which the figures are annexed, represent tens; those of the second order, units; those of the third order, the halves of these units. If the whole line repre-

sents ten, then the divisions of the first order are units; those of the second, tenths; and the third, twentieths.

In the line of tangents, the divisions to which the numbers are affixed are the degrees expressed by those numbers. Every fifth degree is denoted by a line somewhat longer than the rest; between every number and each fifth degree there ar four divisions longer than the intermediate adjacent ones; these are whole degrees; the shorter ones, or those of the third order, are 30 minutes.

From the centre to 60 degrees *the line of sines* is divided like the line of tangents; from 60 to 70 it is divided only to every degree; from 70 to 80 to every two degrees; from 80 to 90 the division must be estimated by the eye.

The divisions on *the line of chords* are to be estimated in the same manner as the tangents.

The *lesser line of tangents* is graduated every two degrees from 45 to 50; but from 50 to 60 to every degree; from 60 to the end to half-degrees.

The *line of secants* from 0 to 10 is to be estimated by the eye; from 20 to 50 it is divided to every two degrees; from 50 to 60 to every degree; and from 60 to the end to every half-degree.

The solution of questions on the sector is said to be *simple* when the work is begun and ended on the same line; *compound* when the operation begins on one line and is finished on the other.

The operation varies also by the manner in which the compasses are applied to the sector. If a measure be taken on any of the sectoral lines beginning at the centre, it is called a *lateral distance*. But if the measure be taken from any point in one line to its corresponding point on the line of the same denomination on the other leg, it is called *a transverse* or *parallel distance*.

The divisions of each sectoral line are bounded by three parallel lines; the innermost of these is that on which the points of the compasses are to be placed, because this alone is the line which goes to the centre, and is alone, therefore, the sectoral line.

We shall now proceed to give a few general instances of the manner of operating with the sector.

Multiplication by the line of lines. Make the lateral distance of one of the factors the parallel distance of 10; then the parallel distance of the other factor is the product.

Example. Multiply 5 by 6: extend the compasses from the

centre of the sector to 5 on the primary divisions, and open the sector till this distance become the parallel distance from 10 to 10 on the same divisions; then the parallel distance from 6 to 6, extended from the centre of the sector, shall reach to 3, which is now to be reckoned 30. At the same opening of the sector, the parallel distance of 7 shall reach from the centre to 35, that of 8 shall reach from the centre to 40, &c.

Division by the line of lines. Make the lateral distance of the dividend the parallel distance of the divisor, the parallel distance of 10 is the quotient. Thus, to divide 30 by 5, make the lateral distance of 30, viz. 3 on the primary divisions, the parallel distance of 5 of the same divisions; then the parallel distance of 10, extended from the centre, shall reach to 6.

Proportion by the line of lines. Make the lateral distance of the second term the parallel distance of the first term; the parallel distance of the third term is the fourth proportional.

Example. To find a fourth proportional to 8, 4, and 6, take the lateral distance of 4, and make it the parallel distance of 8, then the parallel distance of 6, extended from the centre, shall reach to the fourth proportional 3.

In the same manner a third proportional is found to two numbers. Thus, to find a third proportional to 8 and 4, the sector remaining as in the former example, the parallel distance of 4, extended from the centre, shall reach to the third proportional 2. In all these cases, if the number to be made a parallel distance be too great for the sector, some aliquot part of it is to be taken, and the answer multiplied by the number by which the first number was divided. Thus, if it were required to find a fourth proportional to 4, 8, and 6, because the lateral distance of the second term 8 cannot be made the parallel distance of the first term 4, take the lateral distance of 4, viz. the half of 8, and make it the parallel distance of the first term 4; then the parallel distance of the third term 6 shall reach from the centre to 6, viz. the half of 12. Any other aliquot part of a number may be used in the same way. In like manner, if the number proposed be too small to be made the parallel distance, it may be multiplied by some number, and the answer is to be divided by the same number.

To protract angles by the line of chords. Case 1. When the given degrees are under 60. 1. With any radius on a centre, describe the arch. 2. Make the same radius a transverse distance between 60 and 60 on the same line of chords. 3. Take out the transverse distance of the given degrees, and lay this on the arch, which will mark out the angular distance required.

Case 2. When the given degrees are more than 60. 1. Open th sector, and describe the arch as before. 2. Take $\frac{1}{2}$ or $\frac{1}{3}$ of the given degrees, and take the transverse distance of this $\frac{1}{2}$ or $\frac{1}{3}$, and lay it off twice if the degrees were halved, three times if the third was used as a transverse distance.

Case 3. When the required angle is less than 6 degrees; suppose 3. 1. Open the sector to the given radius, and describe the arch as before. 2. Set off the radius. 3. Set off the chord of 57 degrees backwards, which will give the arc of three degrees.

Given the radius of a circle (suppose equal to two inches), required the sine and tangent of 28° 30′ *to that radius.*

Solution.—Open the sector so that the transverse distance of 90 and 90 on the sines, or of 45 and 45 on the tangents, may be equal to the given radius, viz. two inches; then will the transverse distance of 28° 30′, taken from the sines, be the length of that sine to the given radius; or if taken from the tangents, will be the length of that tangent to the given radius.

But if the secant of 28° 30′ *was required?*

Make the given radius, two inches, a transverse distance to 0 and 0 at the beginning of the line of secants; and then take the transverse distance of the degrees wanted, viz. 28° 30′.

A tangent greater than 45° (*suppose* 60°) *is found thus.*

Make the given radius, suppose two inches, a transverse distance to 45 and 45 at the beginning of the scale of upper tangents; and then the required number 60° may be taken from this scale.

Given the length of the sine, tangent, or secant of any degrees, to find the length of the radius to that sine, tangent, or secant.

Solution.—Make the given length a transverse distance to its given degrees on its respective scale: then,

In the sines. The transverse distance of 90 and 90 will be the radius sought.

In the lower tangents. The transverse distance of 45 and 45, near the end of the sector, will be the radius sought.

In the upper tangents. The transverse distance of 45 and 45, taken towards the centre of the sector on the line of upper tangents, will be the centre sought.

In the secant. The transverse distance of 0 and 0, or the beginning of the secants, near the centre of the sector, will be the radius sought.

Given the radius and any line representing a sine, tangent, or secant, to find the degrees corresponding to that line.

Solution.—Set the sector to the given radius, according as a sine, or tangent, or secant is concerned.

Take the given line between the compasses; apply the two feet transversely to the scale concerned, and slide the feet along till they both rest on like divisions on both legs; then will those divisions show the degrees and parts corresponding to the given line.

To find the length of a versed sine to a given number of degrees, and a given radius.

Make the transverse distance of 90 and 90 on the sines equal to the given radius.

Take the transverse distance of the sine complement of the given degrees.

If the given degrees are less than 90, the difference between the sine complement and the radius gives the versed sine.

If the given degrees are more than 90, the sum of the sine complement and the radius gives the versed sine.

To open the legs of the sector so that the corresponding double scales of lines chords, sines, and tangents may make each a right angle.

On the lines, make the lateral distance 10 a distance between 8 on one leg and 6 on the other leg.

On the sines, make the lateral distance 90 a transverse distance from 45 to 45; or from 40 to 50; or from 30 to 60; or from the sine of any degrees to their complement.

Or on the sines, make the lateral distance of 45 a transverse distance between 30 and 30.

OF THE PLAIN SCALE.

The divisions laid down on the plain scale are of two kinds, the one having more immediate relation to the circle and its properties, the other being merely concerned with dividing straight lines.

Though arches of a circle are the most natural measure of an angle, yet in many cases right lines are substituted, as being more convenient; for the comparison of one right line with another is more natural and easy than the comparison of a right line with a curve: hence it is usual to measure the quantities of angles, not by the arch itself, which is described on the angular point, but by certain lines described about that arch.

The lines laid down on the plain scales for the measuring of angles, or the protracting scales, are, 1. A line of *chords* marked CHO. 2. A line of *sines* marked SIN., of *tangents* marked TAN., of *semitangents* marked ST., and of *secants* marked SEC.; this last is often upon the same line as the sines, because its gradations do not begin till the sines end.

There are two other scales, namely, the *rhumbs* marked RU and *longitudes* marked LON. Scales of latitude and hours are sometimes put upon the plain scale; but as dialling is now but seldom studied, they are only made to order.

The divisions used for measuring straight lines are called *scales of equal parts*, and are of various lengths for the convenience of delineating any figure of a larger or smaller size, according to the fancy or purposes of the draughtsman. They are, indeed, nothing more than a measure in miniature for laying down upon paper, &c. any known measure, as chains, yards, feet, &c., each part on the scale answering to one foot, one yard, &c., and the plan will be larger or smaller as the scale contains a smaller or a greater number of parts in an inch. Hence a variety of scales is useful to lay down lines of any required length, and of a convenient proportion with respect to the size of the drawing. If none of the scales happen to suit the purpose, recourse should be had to the *line of lines* on the sector; for, by the different openings of that instrument, a line of any length may be divided into as many equal parts as any person chooses.

Scales of equal parts are divided into two kinds, the one simply, the other diagonally divided.

Six of the simply divided scales are generally placed one above another upon the same rule; they are divided into as many equal parts as the length of the rule will admit of; the numbers placed on the right-hand show how many parts in an inch each scale is divided into. The upper scale is sometimes shortened for the sake of introducing another, called the line of chords.

The first of the larger or primary divisions on every scale is subdivided into ten equal parts, which small parts are those which give a name to the scale: thus it is called a scale of 20, when 20 of these divisions are equal to one inch. If, therefore, these less divisions be taken as units, and each represents one league, one mile, one chain, or one yard, &c., then will the larger divisions be so many tens; but if the subdivisions are supposed to be tens, the larger divisions will be hundreds.

To illustrate this, suppose it were required to set off from either of the scales of equal parts $\frac{36}{10}$, 36, or 360 parts, either miles or leagues. Set one foot of your compasses on 3, among the larger or primary divisions, and open the other point till it falls on the sixth subdivision, reckoning backwards or towards the left hand. Then will this extent represent $\frac{36}{10}$, 36, or 360 miles or leagues, &c. and bear the same proportion in the plan as the line measured does to the thing represented.

To adapt these scales to feet and inches, the first primary division is often duodecimally divided by the upper line; therefore, to lay down any number of feet and inches, as, for instance, 8 feet 8 inches, extend the compasses from 8 of the larger to 8 of the upper small ones, and that distance laid down on the plan will represent 8 feet 8 inches.

Of the scale of equal parts diagonally divided. The use of this scale is the same as those already described. But by it a plane may be more accurately divided than by the former; for any one of the larger divisions may by this be subdivided into 100 equal parts; and, therefore, if the scale contains 10 of the larger divisions, any number under 1000 may be laid down with accuracy.

The diagonal scale is seldom placed on the same side of the rule with the other plotting scale. The first division of the diagonal scale, if it be a foot long, is generally an inch divided into 100 equal-parts, and at the opposite there is usually half an inch divided into 100 equal parts. If the scale be six inches long, one end has commonly half an inch, the other a quarter of an inch, subdivided into 100 equal parts.

The nature of this scale will be better understood by considering its construction. For this purpose,

First. Draw eleven parallel lines at equal distances; divide the upper of these lines into such a number of equal parts as the scale to be expressed is intended to contain; from each of these divisions draw perpendicular lines through the eleven parallels.

Secondly. Subdivide the first of these divisions into ten equal parts, both in the upper and lower lines.

Thirdly. Subdivide again each of these subdivisions, by drawing diagonal lines from the 10th below to the 9th above; from the 8th below to the 7th above; and so on, till from the first below to the 0 above; by these lines each of the small divisions is divided into ten parts, and consequently the whole first space into 100 equal parts; for as each of the subdivisions is one-tenth part of the whole first space or division, so each parallel above it is one-tenth of such subdivision, and consequently, one-hundredth part of the whole first space; and if there be ten of the larger divisions, one thousandth part of the whole space.

If, therefore, the larger divisions be accounted as units, the first subdivisions will be tenth parts of a unit, and the second, marked by the diagonal upon the parallels, hundredth parts of the unit. But if we suppose the larger divisions to be tens, the first subdivisions will be units and the second tenths. If

the larger are hundreds, then will the first be tens and the second units.

The numbers, therefore, 576, 57,6, 5,76, are all expressible by the same extent of the compasses: thus, setting one foot in the number 5 of the larger divisions, extend the other along the sixth parallel to the seventh diagonal. For, if the five larger divisions be taken for 500, seven of the first subdivisions will be 70, which upon the sixth parallel, taking in six of the second subdivisions for units, makes the whole number 576. Or, if the five larger divisions be taken for five tens, or 50, seven of the first subdivisions will be seven units, and the six second subdivisions upon the sixth parallel will be six tenths of a unit. Lastly, if the five larger divisions be only esteemed as five units, then will the seven first subdivisions be seven tenths, and the six second subdivisions be the six hundredth parts of a unit.

Of the line of chords. This line is used to set off an angle from a given point in any right line, or to measure the quantity of an angle already laid down.

Thus, to draw a line that shall make with another line an angle containing a given number of degrees, suppose 40 degrees.

Open your compasses to the extent of 60 degrees upon the line of chords (which is always equal to the radius of the circle of projection), and setting one foot in the angular point, with that extent describe an arch; then taking the extent of 40 degrees from the said chord line, set it off from the given line on the arch described; a right line drawn from the given point through the point marked upon the arch will form the required angle.

The degrees contained in an angle already laid down are found nearly in the same manner. For instance, to measure an angle: from the centre describe an arch with the chord of 60 degrees, and the length of the arch contained between the lines measured on the line of chords will give the number of degrees contained in the angle.

If the number of degrees are more than 90, they must be measured upon the chords at twice: thus, if 120 degrees were to be practised, 60 may be taken from the chords, and those degrees be laid off twice upon the arch. Degrees taken from the chords are always to be counted from the beginning of the scale.

Of the rhumb line. This is, in fact, a line of chords constructed to a quadrant divided into eight parts or points of the compass, in order to facilitate the work of the navigator in laying down a ship's course.

Of the line of longitudes. The line of longitudes is a line divided into sixty unequal parts, and so applied to the line of chords as to show, by inspection, the number of equatorial miles contained in a degree on any parallel of latitude. The graduated line of chords is necessary, in order to show the latitudes; the line of longitude shows the quantity of a degree on each parallel in sixtieth parts of an equatorial degree, that is, miles.

The lines of tangents, semitangents and secants serve to find the centres and poles of projected circles in the stereographical projection of the sphere.

The line of sines is principally used for the orthographic projection of the sphere.

The lines of latitudes and hours are used conjointly, and serve very readily to mark the hour lines in the construction of dials: they are generally on the most complete sorts of scales and sectors; for the uses of which see treatises on dialling.

OF THE PROTRACTOR.

This is an instrument used to protract or lay down an angle containing any number of degrees, or to find how many degrees are contained in any given angle. There are two kinds put into cases of mathematical drawing instruments; one in the form of a semicircle, the other in the form of a parallelogram. The circle is undoubtedly the only natural measure of angles; when a straight line is therefore used the divisions thereon are derived from a circle or its properties, and the straight line is made use of for some relative convenience: it is thus the parallelogram is often used as a protractor instead of the semicircle, because it is in some cases more convenient, and that other scales, &c. may be placed upon it.

The semicircular protractor is divided into 180 equal parts or degrees, which are numbered at every tenth degree each way, for the conveniency of reckoning either from the right towards the left, or from the left towards the right; or the more easily to lay down an angle from either end of the line, beginning at each end with 10, 20, &c. and proceeding to 180 degrees. The edge is the diameter of the semicircle, and the mark in the middle points out the centre, in a *protractor in the form of a parallelogram:* the divisions are, as in the semicircular one, numbered both ways; the blank side represents the diameter of a circle. The side of the protractor to be applied to the paper is made flat, and that whereon the degrees are marked is chamfered or sloped away to the edge, that an angle

may be more easily measured, and the divisions set off with greater exactness.

Application of the protractor to use. 1. *A number of degrees being given, to protract or lay down an angle whose measure shall be equal thereto.*

Thus, to lay down an angle of 60 degrees from the point of a line, apply the diameter of the protractor to the line, so that the centre thereof may coincide exactly with the extremity; then, with a protracting pin make a fine dot against 60 upon the limb of the protractor; now remove the protractor, and draw a line from the extremity through that point, and the angle contains the given number of degrees.

2. *To find the number of degrees contained in a given angle.*

Place the centre of the protractor upon the angular point, and the fiducial edge or diameter exactly upon the line; then the degree upon the limb that is cut by the line will be the measure of the given angle, which, in the present instance is found to be 60 degrees.

3. *From a given point in a line to erect a perpendicular to that line.*

Apply the protractor to the line, so that the centre may coincide with the given point, and the division marked 90 may be cut by the line; then a line drawn against the diameter of the protractor will be the perpendicular required.

OF PARALLEL RULES.

Parallel lines occur so continually in every species of mathematical drawing, that it is no wonder so many instruments have been contrived to delineate them with more expedition than could be effected by the general geometrical methods. For this purpose *rules* of various constructions have been made, and particularly recommended by their inventors; their use, however, is so apparent as to need no explanation.

GUNTER'S SCALE.

The scale generally used is a ruler two feet in length, having drawn upon it equal parts, chords, sines, tangents, secants, &c. These are contained on one side of the scale, and the other side contains the logarithms of these numbers. *Mr. Edmund Gunter* was the first who applied the logarithms of numbers and of sines and tangents to straight lines drawn on a scale or ruler, with which proportions in common numbers and trigonometry may be solved by the application of a pair of compasses only. The method is founded on this property,

That the logarithms of the terms of equal ratios are equidifferent. This was called Gunter's Proportion and Gunter's Line; hence the scale is generally called the Gunter.

Of the Logarithmical Lines on Gunter's Scale.

The logarithmical lines on Gunter's Scale are the eight following:

S. Rhumb, or sine rhumbs, is a line containing the logarithms of the natural sines of every point and quarter point of the compass, numbered from a brass pin on the right-hand towards the left with 8, 7, 6, 5, 4, 3, 2, 1.

T. Rhumb, or tangent rhumbs, also corresponds to the logarithms of the tangent of every point and quarter point of the compass. This line is numbered from near the middle of the scale with 1, 2, 3, 4, towards the right-hand, and back again with the numbers 5, 6, 7, from the right-hand towards the left. To take off any number of points below 4, we must begin at 1 and count towards the right-hand; but to take off any number of points above 4, we must begin at 4 and count towards the left-hand.

Numbers, on the line of numbers, is numbered from the left-hand of the scale towards the right, with 1, 2, 3, 4, 5, 6, 7, 8, 9, 1, which stands exactly in the middle of the scale; the numbers then go on 2, 3, 4, 5, 6, 7, 8, 9, 10, which stands at the right-hand end of the scale. These two equal parts of the scale are divided equally, the distance between the first or left-hand 1 and the first 2, 3, 4, &c. is exactly equal to the distance between the middle 1 and numbers 2, 3, 4, &c. which follow it. The subdivisions of these scales are likewise similar, viz. they are each one-tenth of the primary divisions, and are distinguished by lines of about half the length of the primary divisions.

These subdivisions are again divided into ten parts, where room will permit; and where that is not the case the units must be estimated or guessed at by the eye, which is easily done by a little practice.

The primary divisions on the second part of the scale are estimated according to the value set upon the unit on the left-hand of the scale: if you call it one, then the first 1, 2, 3, &c. stand for 1, 2, 3, &c.; the middle 1 is 10, and the 2, 3, 4, &c. following stand for 20, 30, 40, &c.; and the 10 at the right-hand is 100. If the first 1 stand for 10, the first 2, 3, 4, &c. must be counted 20, 30, 40, &c.; the middle 1 will be 100, and the second 2, 3, 4, 5, &c. will stand for 200, 300, 400, 500, &c.; and the 10 at the right for 1000.

If you consider the first 1 as $\frac{1}{10}$ of a unit, the 2, 3, 4, &c

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following will be $\frac{2}{10}$, $\frac{3}{10}$, $\frac{4}{10}$, &c.; the middle 1 will stand for a unit, and the 2, 3, 4, &c. following will stand for 2, 3, 4, &c.; also, the division at the right-hand end of the scale will stand for 10. The intermediate small divisions must be estimated according to the value set upon the primary ones.

Sine. The line of sines is numbered from the left-hand of the scale towards the right, 1, 2, 3, 4, 5, &c. to 10; then 20, 30, 40, &c. to 90, where it terminates just opposite 10 on the line of numbers.

Versed sine. This line is placed immediately under the line of sines, and numbered in a contrary direction, viz. from the right-hand towards the left, 10, 20, 30, 40, 50, to about 160; the small divisions are here to be estimated according to the number of them to a degree. By comparing the line of versed sines with the line of sines, it will appear that the versed sines do not belong to the arches with which they are marked, but are the half versed sines of their supplements. Thus, what is marked the versed sine of 90 is only half the versed sine of 90, the versed sine of 120° is half the versed sine of 60°, and the versed sine marked 100° is half the versed sine of 80°, &c.

The versed sines are numbered in this manner to render them more commodious in the solution of trigonometrical and astronomical problems.

Tangents. The line of tangents begins at the left-hand, and is numbered 1, 2, 3, &c. to 10, then 20, 30, 45, where there is a little brass pin just under 90 in the line of sines, because the sine of 90° is equal to the tangent of 45°. It is numbered from 45° towards the left-hand 50, 60, 70, 80, &c. The tangents of arches above 45° are therefore counted backward on the line, and are found at the same points of the line as the tangents of their complements.

Thus the division at 40 represents both 40 and 50, the division at 30 serves for 30 and 60, &c.

Meridional Parts. This line stands immediately above a line of equal parts, marked *Equal Pt.*, with which it must always be compared when used. The line of equal parts is marked from the right-hand to the left with 0, 10, 20, 30, &c.; each of these large divisions represents 10 degrees of the equator, or 600 miles. The first of these divisions is sometimes divided into 40 equal parts, each representing 15 minutes or miles.

The extent from the brass pin on the scale of meridional parts to any *division* on that scale, applied to the line of equal parts, will give (in degrees) the meridional parts answering to

the latitude of that *division*. Or the extent from any *division* to another on the line of meridional parts, applied to the line of equal parts, will give the meridional difference of latitude between the two places denoted by the *divisions*. These degrees are reduced to leagues by multiplying by 20, or to miles by multiplying by 60.

The use of the Logarithmical Lines on Gunter's Scale.

By these lines and a pair of compasses all the problems of trigonometry, &c. may be solved.

These problems are all solved by proportion. Now, in natural numbers the quotient of the first term by the second is equal to the quotient of the third by the fourth: therefore, logarithmically speaking, the difference between the first and second term is equal to the difference between the third and fourth; consequently, on the lines on the scale the distance between the first and second term will be equal to the distance between the third and fourth. And for a similar reason, because four proportional quantities are alternately proportional, the distance between the first and third terms will be equal to the distance between the second and fourth. Hence the following

General Rule.

The extent of the compasses from the first term to the second will reach, in this same direction, from the third to the fourth term. Or, the extent of the compasses from the first term to the third will reach, in the same direction, from the second to the fourth.

By the same direction in the foregoing rule is meant, that if the second term lie on the right-hand of the first the fourth will lie on the right-hand of the third, and the contrary. This is true, except the two first or two last terms of the proportion are on the line of tangents, and neither of them under 45°; in this case, the extent on the tangents is to be made in a contrary direction: for had the tangents above 45° been laid down in their proper direction, they would have extended beyond the length of the scale towards the right-hand; they are therefore, as it were, folded back upon the tangents below 45°, and consequently lie in a direction contrary to their proper and natural order.

If the two last terms of a proportion be on the line of tangents, and one of them greater and the other less than 45°, the extent from the first term to the second will reach from the third beyond the scale. To remedy this inconvenience, apply the extent between the two first terms from 45° backward upon the line of tangents, and keep the left-hand point of the

compasses where it falls; bring the right-hand point from 45° to the third term of the proportion; this extent now in the compasses applied from 45° backward will reach to the fourth term, or the tangent required. For, had the line of tangents been continued forward beyond 45°, the divisions would have fallen above 45° forward, in the same manner as they fall under 45° backward.

SECTION V.

TRIGONOMETRY.

The word *Trigonometry* signifies the measuring of triangles. But under this name is generally comprehended the art of determining the positions and dimensions of the several unknown parts of extension, by means of some parts which are already known. If we conceive the different points which may be represented in any space to be joined together by right lines, there are three things offered for our consideration; 1, the length of these lines; 2, the angles which they form with one another; 3, the angles formed by the planes in which these lines are drawn, or are supposed to be traced. On the comparison of these three objects depends the solution of all questions that can be proposed concerning the measure of extension and its parts; and the art of determining all these things from the knowledge of some of them is reduced to the solution of these two general questions.

1. Knowing three of the six parts, the sides and angles, which constitute a rectilineal triangle, to find the other three.

2. Knowing three of the six parts which compose a spherical triangle, that is, a triangle formed on the surface of a sphere by three arches of circles which have their centre in the centre of the same sphere, to find the other three.

The first question is the object of what is called Plane Trigonometry, because the six parts considered here are in the same plane: it is also denominated Rectilineal Trigonometry. The second question belongs to Spherical Trigonometry, wherein the six parts are considered in different planes. But the only object here is to explain the solutions of the former question, viz.

PLANE TRIGONOMETRY.

Plane Trigonometry is that branch of Geometry which

teaches how to determine or calculate three of the six parts of a rectilineal triangle, by having the other three parts given or known. It is usually divided into Right-angled and Oblique-angled Trigonometry, according as it is applied to the mensuration of right or oblique-angled triangles.

In every triangle or case in trigonometry three of the parts must be given, and one of these parts at least must be a side; because, if the three angles only were given, it is obvious that all similar triangles would answer the question.

RIGHT-ANGLED PLANE TRIGONOMETRY.

PL. 5. *fig*. 1.

1. In every right-angled plane triangle ABC, if the hypothenuse AC be made the radius, and with it a circle or an arc of one be described from each end, it is plain (from def. 20), that BC is the sine of the angle A, and AB is the sine of the angle C; that is, the legs are the sines of their opposite angles.*

* The sine and co-sine of any number of degrees and minutes is found by the series (which is given and illustrated in page 49, Ryan's *Differential and Integral Calculus*)

$a-\frac{a^3}{2\cdot3}+\frac{a^5}{2\cdot3\cdot4\cdot5}-\frac{a^7}{2\cdot3\cdot4\cdot5\cdot6\cdot7}$, &c. for its sine, and its co-sine by $1-\frac{a^2}{2}+\frac{a^4}{2\cdot3\cdot4}-\frac{a^6}{2\cdot3\cdot4\cdot5\cdot6}+\frac{a^8}{2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8}$, &c.

In which series the value of a is found thus: as the number of degrees or minutes in the whole semicircle is to the degrees or minutes in the arc proposed, so is 3.14159, &c. to the length of the said arc, which is the value of a. For example, let it be required to find the sine of one minute; then, as 10800 (the minutes in 180 degrees) : 1 : : 3.14159, &c. : .000290888208665 = the length of an arc of one minute, which is the value of a in this case, and $\frac{a^3}{2\cdot3}\left(=\frac{a^3}{6}\right)=.00000000000410$2, &c. Consequently, .000290888208665 — .000000000004102 = .000290888204563 = the required sine of one minute.

Again, let it be required to find the sine and co-sine of five degrees, each true to seven places of decimals. Here, .0002908882, the length of an arc of one minute (found above), being multiplied by 300, the number of minutes in 5 degrees, the product .08726646 is the length of an arc of 5 degrees; therefore in this case we have

$$
\begin{aligned}
a &= .08726646 \\
-\frac{a^3}{6} &= -.00011076 \\
+\frac{a^5}{120} &= +.00000004 \\
\text{\&c.} & \quad \text{\&c.}
\end{aligned}
$$

Consequently, .08715574 = the sine of 5 degrees. Also, $\frac{a^2}{2}=.00380771$, and $\frac{a^4}{24}=.00000241$; hence 1 — .00380771 + .00000241 = .9961947 = the co-sine of 5 degrees.

Fig. 2.

2. If one leg AB be made the radius, and with it on the point A an arc be described, then BC is the tangent and AC is the secant of the angle A, by def. 22 and 25.

Fig. 3.

3. If BC be made the radius, and an arc be described with it on the point C, then is AB the tangent and AC is the secant of the angle C, as before.

Because the sine, tangent, or secant of any given arc in one circle is to the sine, tangent, or secant of a like arc (or to one of the like number of degrees) in another circle, as the radius of the one is to the radius of the other; therefore the sine, tangent, or secant of any arc is proportional to the sine, tangent, or secant of a like arc, as the radius of the given arc is to 10.000000, the radius from whence the logarithmic sines, tangents, and secants in most tables are calculated; that is,

If AC be made the radius, the sines of the angles A and C, described by the radius AC, will be proportional to the sines of the like arcs or angles in the circle that the tables now mentioned were calculated for. So if BC was required, having the angles and AB given, it will be,

---

After the same manner the sine and co-sine of any other arc may be derived; but the greater the arc is the slower the series will converge, and therefore a greater number of terins must be taken to bring out the conclusion to the same degree of exactness.

Or, having found the sine, the co-sine will be found from it (by theo. 14), the co-sine CL (plate 1, fig. 8) $= \sqrt{CH^2, HL^2}$, or $c = \sqrt{1 - s^2}$.

For other methods of constructing the canon of sines and co-sines, the reader is referred to Hutton's Mathematics, Simpson's Algebra, &c.

The sines and co-sines being known or found by the foregoing method, the tangents and secants will be easily found from the principle of similar triangles, in the following manner:

In plate 1, fig. 8, where of the arc BH, HL is the sine, CL or FH the co-sine, BK the tangent, CK the secant, DI the co-tangent, and CI the co-secant, the radius being CH, or CB, or CD, the three similar triangles CLH, CBK, CDI give the following proportion (by theo. 14):

1. $CL : LH :: CB : BK$; whence the tangent is known, being a fourth proportional to the co-sine, sine, and radius.

2. $CL : CH :: CB : CK$; whence the secant is known, being a third proportional to the co-sine and radius.

3. $HL : LC :: CD : DI$; whence the co-tangent is known, being a fourth proportional to the sine, co-sine, and radius.

4. $HL : HC :: CD : CI$; whence the co-secant is known, being a third proportional to the sine and radius.

As for the logarithms, sines, tangents, and secants in the tables, they are only the logarithms of the natural sines, tangents, and secants calculated as above.

Fig. 1.

As $S.C : AB :: S.A : BC$.

That is, as the sine of the angle C in the tables is to the length of AB (or sine of the angle C in a circle whose radius is AC), so is the sine of the angle A in the tables to the length of BC (or sine of the same angle in the circle whose radius is AC).

In like manner the tangents and secants represented by making either leg the radius will be proportional to the tangents and secants of a like arc, as the radius of the given arc is to 10.000000, the radius of the tables aforesaid.

Hence it is plain, that if the name of each side of the triangle be placed thereon, a proportion will arise to answer the same end as before: thus, if AC be made the radius, let the word radius be written thereon; and as BC and AB are the sines of their opposite angles, upon the first let $S.A$, or sine of the angle A, and on the other let $S.C$, or sine of the angle C, be written. Then,

When a side is required, it may be obtained by this proportion, viz.

As the name of the side given
  is to the side given,
So is the name of the side required
  to the side required.

Thus, if the angles A and C and the hypothenuse AC were given, to find the sides; the proportion will be

Fig. 1.

1. $R : AC :: S.A : BC$.

That is, as radius is to AC, so is the sine of the angle A to BC. And,

2. $R : AC :: S.C : AB$.

That is, as radius is to AC, so is the sine of the angle C to AB.

When an angle is required we use this proportion, viz.

As the side that is made the radius
  is to radius,
So is the other given side
  to its name.

Thus, if the legs were given, to find the angle A, and if AB be made the radius, it will be

Fig. 2.

$AB : R :: BC : T.A$.

That is, as AB is to radius, so is BC to the tangent of the angle A.

After the same manner, the sides or angles of all right-angled plane triangles may be found, from their proper data.

We here, in plate 4, give all the proportion requisite for the solution of the six cases in right-angled trigonometry; making every side possible the radius.

In the following triangles this mark — in an angle denotes it to be known, or the quantity of degrees it contains to be given; and this mark ′ on a side denotes its length to be given in feet, yards, perches, or miles, &c. and this mark °, either in an angle or on a side, denotes the angle or side to be required.

From these propositions it may be observed, that to find a side, when the angles and one side are given, any side may be made the radius; and to find an angle, one of the given sides must be made the radius. So that in the 1st, 2d, and 3d cases any side, as well required as given, may be made the radius, and in the first statings of the 4th, 5th, and 6th cases, a given side only is made the radius.

RIGHT-ANGLED TRIANGLES.

Case I.

The angles and hypothenuse given, to find the base and perpendicular.

Pl. 5. *fig.* 4.

In the right-angled triangle ABC, suppose the angle $A=46^\circ\ 30'$; and consequently the angle $C=43^\circ\ 30'$ (by cor. 2, theo. 5); and AC 250 parts (as feet, yards, miles, &c.); required the sides AB and BC.

1st. *By Construction.*

Make an angle of $46^\circ\ 30'$ in blank lines (by prob. 16, geom.), as CAB; lay 250, which is the given hypothenuse, from a scale of equal parts, from A to C; from C let fall the perpendicular BC (by prob. 7, geom.), and that will constitute the triangle ABC. Measure the lines BC and AB from the same scale of equal parts that AC was taken from, and you have the answer.*

* It is proper to observe, that constructions, though perfectly correct in theory, would give only a moderate approximation in practice, on account of the imperfection of the instruments required in constructing them, they are called *graphic methods*. Trigonometrical methods, on the contrary, being independent of all mechanical operation, give solutions with the utmost accuracy: they are founded upon the properties of lines called *sines*, *co-sines*, *tangents*, &c., which furnish a very simple mode of expressing the relations that subsist between the sides and angles of triangles.

2d. *By Calculation.*

1. *Making AC the radius*, the required sides are found by these propositions, as in plate 4, case 1.

$R : AC :: S.A : BC.$

$R : AC :: S.C : AB.$

That is, as radius	$=90°$	10.000000
is to *AC*,	$=250$	2.397940
So is the sine of $A=46° 30'$*		9.860562
to *BC*,	$=181.4$	2.258502

As radius	$=90°$	10.000000
is to *AC*,	$=250$	2.397940
So is the sine of $C=43° 30'$		9.837812
to *AB*,	$=172.1$	2.235752

If from the sum of the second and third logs. that of the first be taken, the number will be the log. of the fourth; the number answering to which will be the thing required; but when the first log. is radius, or 10.000000, reject the first figure of the sum of the other two logs. (which is the same thing as to subtract 10.000000), and that will be the log. of the thing required.

2. *Making AB the radius.*

Secant $A : AC :: R : AB.$

Secant $A : AC :: T.A : BC.$

That is, as the secant of $A=46° 30'$		10.162188
is to *AC*,	$=250$	2.397940
So is the radius	$=90°$	10.000000
		12.397940
to *AB*,	$=172.1$	2.235762

As the secant of *A*	$=46° 30'$	10.162188
is to *AC*,	$=250$	2.397940
So is the tangent of $A=46° 30'$		10.022750
		12.420690
to *BC*,	$=181.34$	2.258502

* For finding the logarithmic sine, co-sine, &c. of any number of degrees and minutes in the table, also the degrees, minutes, &c. of any logarithmic sine, co-sine, &c., the reader is referred to table 2, at the end of this treatise.

2. *Making BC the radius.*

Sec. $C : AC :: R : BC$.

Sec. $C : AC :: T.C : AB$.

That is, as the secant of C	$=43° 30'$	10.139438
is to AC,	$=250$	2.397940
So is the radius	$=90°$	10.000000
		12.397940
to BC,	$=181.34$	2.258502
As the secant of C	$=43° 30'$	10.139438
is to AC,	$=250$	2.397940
So is the tangent of C	$=43° 30'$	9.977250
		12.375190
to AB,	$=172.1$	2.235752

Or, having found one side, the other may be obtained by cor. 2, theo. 14, sect. 4.

3d. *By Gunter's Scale.*

The first and third terms in the foregoing proportions being of a like nature, and those of the second and fourth being also like to each other; and the proportions being direct ones; it follows, that if the third term be greater or less than the first, the fourth term will be also greater or less than the second: therefore the extent in your compasses from the first to the third term will reach from the second to the fourth.

Thus, to extend the first of the foregoing proportions;

1. Extend from 90° to 46° 30', on the line of sines; that distance will reach from 250, on the line of numbers, to 181, for BC.

2. Extend from 90° to 43° 30', on the line of sines; that distance will reach from 250, on the line of numbers, to 172, for AB.

If the first extent be from a greater to a less number; when you apply one point of the compasses to the second term, the other must be turned to a less; and the contrary.

By def. 20, sect. 4. The sine of 90° is equal to the radius; and the tangent of 45° is also equal to the radius; because if one angle of a right-angled triangle be 45°, the other will be also 45°; and thence (by the lemma preceding theo. 7, sect. 4) the tangent of 45° is equal to the radius: for this reason the line of numbers of 10.000000, the sine of 90°, and tangent of 45°, being all equal, terminate at the same end of the scale.

The first two statings of this case answer the question without a secant; the like will be also made evident in all the following cases.

4th. *Solution by Natural Sines.*

From the foregoing analogies, or statements, it is obvious that if the hypothenuse be multiplied by the natural sine of either of the acute angles, the product will be the length of the side opposite to that angle; and multiplied by the natural cosine of the same angle, the product will be the length of the other side, or that which is contiguous to the angle. Thus:

The given angle=47° 30′

Nat. Sine=.725374	Nat. Cos.=.688355
Hyp.= 250	250
36268700	34417750
1450748	1376710
Perpend.=181.343500	Base=172.088750

CASE II.

The base and angles given, to find the perpendicular and hypothenuse.

PL. 5. *fig.* 5.

In the triangle *ABC*, there is the angle *A* 42° 20′, and of course the angle *C* 47° 40′ (by cor. 2, theo. 5), and the side *AB* 190 given; to find *BC* and *AC*.

1st. *By Construction.*

Make the angle *CAB* (by prop. 16, sect. 4) in blank lines, as before. From a scale of equal parts lay 190 from *A* to *B*, on the point *B* erect a perpendicular *BC* (by prob. 5, sect. 4), the point where this cuts the other blank line of the angle will be *C*; so is the triangle *ABC* constructed: let *AC* and *BC* be measured from the same scale of equal parts that *AB* was taken from, and the answers are found.

2d. *By Calculation.*

1. *Making AC the radius.*

$S.C : AB :: R : AC.$

$S.C : AB :: S.A : BC.$

That is, as the sine of C	$=47° 40'$	9.868785
is to AB,	$=190$	2.278754
So is radius	$=90°$	10.000000
		12.278754
to AC,	$=257$	2.409969
As the sine of C	$=47° 40'$	9.868785
is to AB,	$=190$	2.278754
So is the sine of A	$=42° 20'$	9.828301
		12.107055
to BC,	$=173.1$	2.238270

2. *Making AB the radius.*

$R : AB :: T.A : BC.$

$R : AB :: \text{Sec. } A : AC.$

That is, as radius	$=90°$	10.000000
is to AB,	$=190$	2.278754
So is the tangent of A	$=42° 20'$	9.959516
to BC,	$=173.1$	2.238270
As radius	$=90°$	10.000000
is to AB,	$=190$	2.278754
So is the secant of A	$=42° 20$	10.131215
to AC,	$=257$	2.409969

3. *Making BC the radius.*

$T.C : AB :: \text{Sec. } C : AC$

$T.C : AB :: R : BC.$

That is, as the tangent of C	$=47° 10'$	10.040484
is to AB,	$=190$	2.278754
So is the secant of C	$=47° 40'$	10.171699
		12.450453
to AC,	$=257$	2.409969
As the tangent of C	$=47° 40'$	10.040484
is to AB,	$=190$	2.278754
So is the radius	$=90°$	10.000000
		12.278754
to BC,	$=173.1$	2.238270

Or, having found one of the required sides, the other may be obtained by one or the other of the cors. to theo. 14, sect. 4.

3d. *By Gunter's Scale.*

1. When AC is made the radius.

Extend from 47° 40′ to 90° on the line of sines; that distance will reach from 190 to 257, on the line of numbers, for AC.

2. When AB is made the radius, the first stating is thus performed:

Extend from 45° on the tangents (for the tangent of 45° is equal to the radius, or to the sine of 90° as before) to 42° 20′; that extent will reach from 190, on the line of numbers, to 173, for BC.

3. When BC is made the radius, the second stating is thus performed:

Extend from 47° 40′, on the line of tangents, to 45°, or radius; that extent will reach from 190 to 173, on the line of numbers, for BC; for the tangent of 47° 40′ is more than the radius, therefore the fourth number must be less than the second, as before.

The first two statings of this case answer the question without a secant.

4th. *Solution by Natural Sines.*

$$\frac{AB\times R}{S \text{ of } C.}=AC; \text{ and } \frac{AB\times S \text{ of } A}{S \text{ of } C}=BC.$$

Nat. S. of C. Side $AB\times R$.

Thus, .739239)190.000000(257.02, &c.$=AC$.

$$\begin{array}{r}
147\ 8478 \\
\hline
4215220 \\
3696195 \\
\hline
5190250 \\
5174673 \\
\hline
1557700 \\
1478478
\end{array}$$

and, .673443=Nat. S of A.

190=side AB.

$$\begin{array}{r}
60609870 \\
673443 \\
\hline
127.954170
\end{array}$$

Nat. S of C.739239)127.954170(173.09=BC.
73 9239

5403027
5174673

2283540
2217717

6502300
6653151

CASE III.

The angles and perpendicular given, to find the base and hypothenuse

PL. 5. *fig.* 6.

In the triangle ABC, there is the angle A 40°, and consequently the angle C 50°, with BC 170, given, to find AC and AB.

1st. *By Construction.*

Make an angle CAB of 40° in blank lines (by prob. 16, sect. 4); with BC 170 from a line of equal parts draw the lines EF parallel to AB (by prob. 8, sect. 4), the lower line of the angle, and from the point where it cuts the other line in C let fall a perpendicular BC (by prob. 7, sect. 4), and the triangle is constructed: the measures of AC and AB, from the same scale that BC was taken, will answer the question.

What has been said in the two foregoing cases is sufficient to render the operations in this, both by calculation, Gunter's scale, and natural sines, so obvious, that it is needless to insert them; however, for the sake of the learner, we give for

Answers, AC 264.5, and AB 202.6.

CASE IV.

The base and hypothenuse given, to find the angles and perpendicular.

PL. 5. *fig.* 7.

In the triangle ABC, there is given AB 300 and AC 500; the angles A and C and the perpendicular BC are required.

1st. *By Construction.*

From a scale of equal parts lay 300 from *A* to *B*; on *B* erect an indefinite blank perpendicular line; with *AC* 500 from the same scale, and one foot of the compasses in *A*, cross the perpendicular line in *C*; and the triangle is constructed.

By prob. 17, sect. 4, measure the angle *A*, and let *BC* be measured from the same scale of equal parts that *AC* and *AB* were taken from; and the answers are obtained.

2d. *By Calculation.*

1. *Making AC the radius.*

$AC : R :: AB : S.C.$

$R : AC :: S.A : BC.$

That is, as *AC*	$=500$	2.698970
is to radius,	$=90°$	10.000000
So is *AB*	$=300$	2.477121
		12.477121
to the sine of *C*,	$= 36° \ 52'$	9.778151

By cor. 2, theo. 5, $90°—36° \ 52'=53° \ 08'$, the angle *A*.

As radius	$=90°$	10.000000
is to *AC*,	$=500$	2.698970
So is the sine of *A*	$=53° \ 08'$	9.903108
to *BC*,	$=400$	2.602078

2. *Making AB the radius.*

$AB : R :: AC :: \text{sec. } A.$

$R : AB :: T.A : BC.$

That is, as *AB*	$=300$	2.477121
is to radius,	$=90°$	10.000000
So is *AC*	$=500$	2.698970
		12.698970
to the secant of *A*,	$=53° \ 08'$	10.221849

As radius	$=90°$	10.000000
is to *AB*,	$=300$	2.477121
So is the tangent of *A*	$=53° \ 08'$	10.124990
to *BC*,	$=400$	2.602111

Or *BC* may be found from cor. 2, theo. 14, sect 4.

3d. *By Gunter's Scale.*

1. *Making AC the radius.*

Extend from 500 to 300, on the line of numbers; that extent will reach from 90°, on the line of sines, to 36° 52′ for the angle *C*.

Again, extend from 90° to 53° 08′, on the line of sines, that extent will reach from 500 to 400, on the line of numbers, for *BC*.

2. *Making AC the radius*, the second stating is thus performed.

Extend from radius, or the tangent of 45°, to 53° 08′, that extent will reach from 300 to 400, for *BC*.

4th. *Solution by Natural Sines.**

$$\frac{R \times AB}{AC} = S \text{ of } C; \text{ and } \frac{AC \times S \text{ of } A}{R} = BC,$$

Thus, *AC*, *AB*,

$$5{,}00)300.0000{,}00$$

$$\overline{.600000} = \text{Nat. sine } 36° \ 52'.$$

and,

$$\begin{array}{rcl} \text{Nat. sine of } A = 53° \ 8' & = & .800034 \\ AC & = & 500 \\ \hline & & 400.017000 = BC. \end{array}$$

CASE V.

The perpendicular and hypothenuse given, to find the angles and base.

Pl. 5. *fig.* 8.

In the triangle *ABC* there is *BC* 306 and *AC* 370 given, to find the angles *A* and *C* and the base *AB*.

1st. *By Construction.*

Draw a blank line from any point, in which at *B* erect a perpendicular, on which lay *BC* 306, from a scale of equal parts: from the same scale, with *AC* 370 in the compasses

* For finding the natural sines and co-sines, the reader is referred to table 3.

draw the first drawn blank line in A, and the triangle ABC is constructed.

Measure the angle A (by prob. 17, sect. 4), and also AB, from the same scale of equal parts the other sides were taken from, and the answers are now found.

The operations by calculation, the square root, Gunter's scale, and natural sines are here omitted, as they have been heretofore fully explained: the statings, or proportions, must also be obvious, from what has already been said.

Answers. The angle A 55° 48′; therefore the angle C 34° 12′, and AB 208.

CASE VI.

The base and perpendicular given, to find the angles and hypothenuse.

Pl. 5. *fig.* 9.

In the triangle ABC, there is AB 225 and BC 272 given, to find the angles A and C and the hypothenuse AC.

1st. *By Construction.*

Draw a blank line, on which lay AB 225, from a scale of equal parts; at B erect a perpendicular; on which lay BC 272 from the same scale; join A and C, and the triangle is constructed.

As before, let the angle A and the hypothenuse AC be measured, in order to find the answers.

2d. *By Calculation.*

1. *Making AB the radius.*

$$AB : R :: BC : T.A.$$
$$R : AB :: \text{sec. } A : AC.$$

2. *Making BC the radius.*

$$BC : R :: AB : T.C.$$
$$R : BC :: \text{sec. } C : AC$$

By calculation, the answers from the foregoing proportions are easily obtained as before.

But because AC, by either of the said proportions, is found by means of a secant, and since there is no line of secants on Gunter's scale, after having found the angles as before, let us suppose AC the radius, and then

$$1.\ S.A : BC :: R : AC$$
$$\text{or } 2.\ S.C : AB :: R : AC.$$

These proportions may be easily resolved, either by calculation or Gunter's scale, as before; and thus the hypothenuse AC may be found without a secant.

From the two given sides the hypothenuse may be easily obtained, from cor. 1, theo. 14, sect.

Thus, the square of $AB = 50625$
Add the square of $BC = 73984$

124609(353 $= AC$.
9

65)346
325

703)2109
2109

From what has been said on logarithms, it is plain,

1. That half the logarithm of the sum of the squares of the two sides will be the logarithm of the hypothenuse. Thus,*

The sum of squares, as before, is 124609; its log. is 5.095549, the half of which is 2.547774; and the corresponding number to this in the tables will be 353, for AC.

2. And that half of the logarithm of the difference of the squares of AC and AB, or of AC and BC, will be the logarithm of BC, or of AB.

The following examples are inserted for the exercise of the learner.

Ex. 1. In the right-angled triangle ABC,

Given, { the hypothenuse AC 540 perches, $\angle A$ 33° 45′ } Ans. { BC 300, AB 449 }

To find the other two sides.

Ex. 2. In the right-angled triangle ABC,

Given, { the base AB 162 chains, $\angle A$ 33° 45′ } Ans. { AC 270, BC 216 }

To find the other two sides.

* Demonstration. The square of the hypothenuse of a right-angled triangle is equal to the sum of the squares of the sides (theo. 14); hence the log. of ($AC^2 AB^2$) = the log. of BC^2, and by the nature of logarithms the log. of BC is equal to the log. of BC^2 divided by 2; and in like manner the log. of ($AB^2 + BC^2$) = the log. of AC^2, hence dividing the log. of AC^2 by 2 gives the log. of AC. Q. E. D.

Ex. 3. In the right-angled triangle ABC,

Given, { the perpendicular BC 180 links, $<C$ 62° 40′ } Ans. { AC 392.0146, AB 348.2464 }

To find the other two sides.

Ex. 4. In the right-angled triangle ABC,

Given, { the hypothenuse AC 392 poles, the base AB 180 poles } Ans. { $<A$ 62° 40′, $<C$ 27° 20′, BC 348.25 }

To find the angles and perpendicular.

Ex. 5. In the right-angled triangle ABC,

Given, { the hypothenuse AC 1198 chains, the perpendicular BC 980 chains } Ans. { $<A$ 54° 51′, $<C$ 35° 09′, AB 690 }

To find the angles and base.

Ex. 6. In the right-angled triangle ABC,

Given, { the base AB 735.9 links, the perpendicular BC 320 } Ans. { $<C$ 66° 30′, $<A$ 23° 30′, AC 802.5 }

To find the angles and hypothenuse.

OBLIQUE-ANGLED PLANE TRIGONOMETRY.

Before we proceed to the solution of the four cases of Oblique-angled triangles, it is necessary to premise the following theorems.

THEOREM I.

Pl. 5. *fig.* 10.

In any plane triangle ABC the sides are proportional to the sines of their opposite angles; that is, S.C : AB : : S.A : BC, and S.C : AB : : S.B : AC; also, S.B : AC : : S.A : BC.

By theo. 10, sect. 4, the half of each side is the sine of its opposite angle; but the sines of those angles, in tabular parts, are proportional to the sines of the same in any other measure; and therefore the sines of the angles will be as the halves of their opposite sides; and since the halves are as the wholes, it follows that the sines of their angles are as their opposite sides; that is, $S.C : AB : : S.A : BC$, &c. Q. E. D.

THEOREM II.

Fig. 11.

In any plane triangle ABC the sum of the two given sides AB and BC, including a given angle ABC, is to their difference as the tangent of half the sum of the two unknown angles A and C is to the tangent of half their difference.

Produce AB, and make $HB=BC$, and join HC: let fall the

perpendicular BE, and that will bisect the angle HBC (by theo. 9, sect. 4); through B draw BD parallel to AC, and make $HF=DC$, and join BF; take $BI=BA$, and draw IG parallel to BD or AC.

It is then plain that AH will be the sum and HI the difference of the sides AB and BC: and since $HB=BC$, and BE perpendicular to HC, therefore $HE=EC$ (by theo. 8, sect. 4); and since $BA=BI$, and BD and IG parallel to AC, therefore $GD=DC=FH$, and consequently $HG=FD$, and $\frac{1}{2}HG=\frac{1}{2}FD$ or ED. Again, EBC, being half HBC, will be also half the sum of the angles A and C (by theo. 4, sect. 4); also, since HB, HF, and the included angle H are severally equal to BC, CD, and the included angle BCD, therefore (by theo. 6, sect. 4) $HBF=DBC=BCA$ (by part 2, theo. 3, sect. 4); and since $HBD=A$ (by part 3, theo. 3, sect. 4), and $HBF=BCA$, therefore FBD is the difference and EBD half the difference of the angles A and C: then making BE the radius, it is plain that EC will be the tangent of half the sum, and ED the tangent of half the difference of the two unknown angles A and C: now IG being parallel to AC, $AH : IH :: CH : GH$ (by cor. 1, theo. 20, sect. 4). But the wholes are as their halves; that is, $AH : IH :: CE : ED$; that is, as the sum of the two sides AB and BC is to their difference, so is the tangent of half the sum of the two unknown angles A and C to the tangent of half their difference. Q. E. D.

THEOREM III.

Fig. 12.

In any right-lined plane triangle ABD, the base AD will be to the sum of the other sides AB, BD as the difference of those sides is to the difference of the segments of the base made by the perpendicular BE; viz. the difference between AE and ED.

Produce BD till $BG=AB$, the lesser leg; and on B as a centre, with the distance BG or BA, describe a circle $AGHF$, which will cut BD and AD in the points H and F; then it is plain that GD will be the sum, and HD the difference of the sides AB and BD; also, since $AE=EF$ (by theo. 8, sect. 4), therefore FD is the difference of AE, ED, the segments of the base; but (by theo. 17, sect. 4) $AD : GD :: HD : FD$; that is, the base is to the sum of the other sides as the difference of those sides is to the difference of the segments of the base. Q. E. D.

Cor. 1. In the above triangle the longest side is made the base, and then the perpendicular falls within the triangle; but if DF (the same construction remaining as in the above, only

joining BF) (fig. 3, plate 14), be considered the base of the triangle BDF, then BE is a perpendicular on the base produced; GD is equal to the sum of the sides BF, BD; HD is equal to their difference: also AD is equal to the sum of the segments DE, EF. But (by theo. 17, sect. 4) $FD \times AD = GD \times HD$, hence $FD : GD :: HD : AD$. That is, as the base is to the sum of the two sides, so is the difference of the sides to the sum of the segments of the base. Q. E. D.

Cor. 2. Hence (by calling any side the base) as the base is to the sum of the sides, so is the difference of the sides to the difference or sum of the segments of the base, according as the perpendicular falls within or without the triangle.*

THEOREM IV.

Fig. 13.

If to half the sum of two quantities be added half their difference, the sum will be the greatest of them; and if from half the sum be subtracted half their difference, the remainder will be the least of them.

Let the two quantities be represented by AB and BC (making one continued line), whereof AB is the greatest, and BC the least. Bisect the whole line AC in E, and make $AD = BC$; then it is plain that AC is the sum, and DB the difference of the two quantities, and AE or EC their half-sum, and DE or EB their half-difference. Now if to AE we add EB, we shall have AB the greatest quantity; and if from EC we take EB, we shall have BC the least quantity. Q. E. D.

Cor. Hence, if from the greatest of two quantities we take half the difference of them, the remainder will be half their sum; or if to half their difference be added the least quantity, their sum will be half the sum of the two quantities.

THEOREM V.

Pl. 14. *fig.* 4.

In any triangle the rectangle under two sides is to the rectangle under the semiperimeter, and its excess above the base, as the square of the radius to the square of the co-sine of half the contained angle.

In the triangle CBE, the perimeter being denoted by P, $CB \times CE : \frac{1}{2}P(\frac{1}{2}P - BE) :: R^2 : \cos. \frac{1}{2}C^2$. Produce EC to A,

* The perpendicular falls within or without the triangle, according as the square of the greater side is less or greater than the sum of the squares of the less side and the base. For a demonstration of which the reader is referred to (Prop. 12, 13, B. 2) Simpson's Euclid.

making $CA=CB$; draw BD perpendicular to CE, bisect CE in H, and join AB.

Let CB be greater than EB, then (by theo. 3, fig. 12) $CE : CB+BE :: CB-BE : \frac{CB^2\ BE^2}{CE}=2HD$, by adding half this to half the base $=CH$. The segment $CD=\frac{CB^2\ BE^2+CE^2}{2.CE}$; to this adding CA, or CB, gives $AD=\frac{CB^2\ BE^2+CE^2+2CE.CB}{2.CE}$ $=\frac{(CB+CE)^2\ BE^2}{2CE}=\frac{CB+CE+BE\times CB+CE-BE}{2CE}$.

Again, $AD=AC+CD=CB+CD$; hence $AD^2=CB^2+2CB.CD+CD^2=2CB.AD$; also, $BD^2=CB^2\ CD^2$; hence $AB^2=AD^2+BD^2=2.CB^2+2CB.CD=2CB\times(CB+CD)$ $=2CB.AD$; therefore, $AD.AB^2=2CB.AD^2$, or $\frac{P(\frac{1}{2}P-BE)}{CE}.$ $AB^2=2CB.AD^2$, or $P(\frac{1}{2}P-BE).AB^2=CE.2CB.AD^2$, dividing both sides by 2; $CE.CB.AD^2=\frac{1}{2}P(\frac{1}{2}P-BE).AB^2$, consequently $CE.CB : \frac{1}{2}P(\frac{1}{2}P-BE) :: AB^2 : AD^2$. That is, $CE\times CB : \frac{1}{2}P\times\frac{1}{2}(P-BE) ::$ rad.^{2} : (cos. $\frac{1}{2}BCE)^2$.* Q. E. D.

OBLIQUE-ANGLED TRIANGLES.

CASE I.

Two sides and an angle opposite to one of them given, to find the other angles and side.

Pl. 5. *fig.* 14.

In the triangle ABC, there is given AB 240, the angle A 46° 30′, and BC 200, to find the angle C, being acute, the angle B, and the side AC.

1st. *By Construction.*

Draw a blank line, on which set AB 240, from a scale of equal parts; at the point A, of the line AB, make an angle of 46° 30′, by an indefinite blank line; with BC 200, from a like scale of equal parts that AB was taken, and one foot in B, describe the arc DC to cut the last blank line in the points D and C. Now if the angle C had been required obtuse, lines from D to B, and to A, would constitute the triangle; but as it is required acute, draw the lines from C to B and to A, and the triangle ABC is constructed. From a line of chords let the angles B and C be measured; and AC from the same scale

* For a different method of demonstrating this theorem, as well as the demonstration of other useful theorems, the reader is referred to Leslie's Geometry (pages 372, 373).

of equal parts that AB and BC were taken; and you will have the answers required.

2. *By Calculation.*

This is performed by theo. 1 of this sect. thus:

As BC	$=200$	2.301030
is to the sine of A,	$=46°30'$	9.860562
So is AB	$=240$	2.380211
		12.240773
to the sine of C,	$=60°\ 31'$	9.939743

180° — the sum of the angles A and C will give the angle B, by cor. 1, theo. 5, sect. 4.

A 46° 30′
C 60 31

180°—107° 1′=72° 59′=B.

As the sine of $A=46°\ 30'$		9.860562
is to BC,	$=200$	2.301030
So is the sine of $B=72°\ 59'$		9.980555
		12.281585
to AC,	$=263.7$	2.421023

3d. *By Gunter's Scale.*

Extend from 200 to 240 on the line of numbers; that distance will reach from 46° 30′, on the line of sines, to 60° 31′, for the angle C.

Extend from 46° 30′ to 72° 59′, on the line of sines; that distance will reach from 200 to 263.7 on the line of numbers, for AC.

Note.—The method by natural sines will be obvious from the foregoing analogies.

If the side opposite the given angle be equal to or greater than the other given side, or the given angle obtuse, then there would be but one answer to the problem, because the angle opposite that other given side will be always acute; but when the given angle is acute, and opposite the less of the given sides, the answer is ambiguous, as the sine of an angle is equal to the sine of its supplement, consequently the required angle opposite that other given side may be obtuse or acute, unless it is given in the conditions of the problem.

In the last problem the given angle is acute, and the side opposite to it less than the other given side, therefore the angle C may be acute or obtuse; but the side and angle answering to the acute value of C has been already found. Now it remains to find the side and angle of the triangle answering to the obtuse value of C, which is thus found:

The acute value of C, found in the foregoing calculation, is $60° 31'$, consequently its obtuse value is $180°-60° 31'=119° 29'$; then $119° 29'+46° 30'$, taken from $180°$, gives $14° 1'=$ to the remaining angle ABC (pl. 14, fig. 5).

To find the side AC, answering to the obtuse value of the angle C.

As the sine of A	$=46° 30'$	9.860562
is to BC,	$=200$	2.301030
So is sine B	$=14° 1'$	9.384182
		11.685212
to the side AC,	$=66.8$	1.824650

CASE II.

Two angles and a side given, to find the other sides.

PL. 5. *fig.* 15.

In the triangle ABC there is the angle A 46° 30', AB 230, and the angle B 37° 30' given, to find AC and BC.

1st. *By Construction.*

Draw a blank line, upon which set AB 230 from a scale of equal parts; at the point A of the line AB make an angle of $46° 30'$, by a blank line; and at the point B of the line AB make an angle of $37° 30'$, by another blank line; the intersection of those lines gives the point C: then the triangle ABC is constructed. Measure AC and BC from the same scale of equal parts that AB was taken, and you have the answer required.

2d. *By Calculation.*

By cor. 1, theo 5, sect 4, $180°$ — the sum of the angles A and $B=C$.

$$\begin{array}{l} A\ 46° 30' \\ B\ 37\ \ 30 \\ \hline \end{array}$$

$$180°-84° 00'=96° 00'=C.$$

By def. 27, sect. 4. The sine of 96° = the sine of 84°, which is the supplement thereof; therefore, instead of the sine of 96°, look in the tables for the sine of 84°.

By theo. 1 of this sect.

As the sine of *C*	=96° 00′	9.997614
is to *AB*,	=230	2.361728
So is the sine of *A*	=46° 30′	9.860562
		12.222290
to *BC*,	=167.8	2.224676

As the sine of *C*	=96° 00′	9.997614
is to *AB*,	=230	2.361728
So is the sine of *A*	=37° 30′	9.784447
		12.146175
to *AC*,	=140.8	2.148561

3d. *By Gunter's Scale.*

Extend from 84° (which is the supplement of 96°) to 46° 30′ on the sines; that distance will reach from 230 to 168, on the line of numbers, for *BC*.

Extend from 84° to 37° 30′, on the sines; that extent will reach from 230 to 141, on the line of numbers, for *AC*.

CASE III.

Two sides and a contained angle given, to find the other angles and side.

PL. 5. *fig.* 16.

In the triangle ABC, there is AB 240, the angle A 36° 40′, and AC 180 given, to find the angles C and B and the side BC.

1st. *By Construction.*

Draw a blank line, on which, from a scale of equal parts, lay *AB* 240; at the point *A* of the line *AB* make an angle of 36° 40′, by a blank line; on which from *A* lay *AC* 180, from the same scale of equal parts; measure the angles *C* and *B* and the side *BC*, as before, and you have the answers required.

2d. *By Calculation.*

By cor. 1, theo. 5, sect. 4, 180° — the angle *A* 36° 40′= 143° 20′, the sum of the angles *C* and *B*: therefore, half of

143° 20′ will be half the sum of the two required angles *C* and *B*.

By theo. 2 of this sect.

As the sum of the two sides *AB* and *AC*=420
is to their difference, = 60
So is the tangent of half the sum of the two unknown angles *C* and *B* } =71° 40′
to the tangent of half their difference,=23° 20′

By theo. 4.

To half the sum of the angles *C* and *B*=71° 40′.
Add half their difference as now found=23° 20′

The sum is the greatest angle, or ang. *C*=95 00

Subtract, and you have the least angle, or *B*=48 20

The angles *C* and *B* being found, *BC* is had as before, by theo. 1 of this sect. Thus,

S.B : *AC* : : *S.A* : *BC*.
48° 20′ : 180 : : 36° 40′ : 143.9.

3d. *By Gunter's Scale.*

Because the two first terms are of the same kind, extend from 420 to 60 on the line of numbers; lay that extent from 45° on the line of tangents, and keeping the left leg of your compasses fixed, move the right leg to 71° 40′; that distance laid from 45° on the same line will reach to 23° 30′, the half-difference of the required angles. Whence the angles are obtained, as before.

The second proportion may be easily extended, from what has been already said.

CASE IV.

PL. 5. *fig.* 17.

The three sides given, to find the angles.

In the triangle ABC, there is given AB 64, *AC* 47, *BC* 34; *the angles A, B, and C are required.*

1st. *By Construction.*

The construction of this triangle must be manifest, from prob. 1, sect. 4.

2d. *By Calculation.*

From the point *C* let fall the perpendicular *CD* on the base *AB*, and it will divide the triangle into two right-angled ones, *ADC* and *CBD*, as well as the base *AB* into the two segments *AD* and *DB*.

AC	47
BC	34
Sum	81
Difference	13

By theo. 3 of this sect.

As the base or the longest side *AB*	64
is to the sum of the other sides *AC* and *BC*,	81
So is the difference of those sides	13
to the difference of the segments of the base *AD*, *DB*,	16.46

By theo. 4 of this sect.

To half the base, or to half the sum of the segments *AD* and *DB*,	32
Add half their difference, now found,	8.23
Their sum will be the greatest segment *AD*,	40.23
Subtract, and their difference will be the least segment, *DB*,	23.77

In the right-angled triangle *ADC*, there is *AC* 47 and *AD* 40.23 given, to find the angle *A*.

This is resolved by case 4 of right-angled plane trigonometry, thus:

$$AD : R : : AC : \text{sec. } A$$
$$40.23 : 90^\circ : : 47 : 31^\circ\ 08'$$

Or it may be had by finding the angle *ACD*, the complement of the angle *A*, without a secant, thus:

$$AC : R : AD : S.ACD$$
$$44 : 90^\circ : : 40.23 : 58^\circ\ 52'$$
$$90^\circ - 58^\circ\ 52' = 31^\circ\ 08', \text{ the angle } A.$$

Then by theo. 1 of this sect.

$$BC : S.A : : AC : S.B$$
$$34 : 31^\circ\ 08' : : 47 : 45^\circ\ 37'$$

By cor. 1, theo. 5, sect. 4, 180° — the sum of A and $B=C$.

A 31° 08′
B 45 37

180°—76 45=103° 15′, the angle C.

3d. *By Gunter's Scale.*

The first proportion is extended on the line of numbers; and it is no matter whether you extend from the first to the third or to the second term, since they are all of the same kind: if you extend to the second, that distance applied to the third will give the fourth; but if you extend from the first to the third, that extent will reach from the second to the fourth.*

The methods of extending the other proportions have been already fully treated of.

RULE 2.

Either of the angles, as A, may be found by adding together the arithmetical complements of the logarithms of the two sides AB, AC, containing the required angle, the log. of the half-sum of the three sides, and the log. of the difference between the half-sum and the side opposite the required angle; then half the sum of these four logarithms will be the logarithmic co-sine of half the required angle.† It is required to find the angle A, in the last problem, by this rule, the sides remaining the same.

	BC=34		
	AC=47	Ar. Co.	7.327902
	AB=64	Ar. Co.	7.193820
	2)145		
Half-sum	72.5	Log.	2.860338
	BC=34		
Difference	38.5	Log.	2.585461
			2)19.967521
Cos. ½ A, 15° 34′			9.983760

Whose double 31° 08′ is the angle A.

* The reader is referred to Hutton's Mathematics, vol. ii. New-York edition, for the method of investigating Plane Trigonometry analytically.

† The demonstration of this rule is evident from theo. 5, and the nature of logarithms; but in working the proportion by logarithms, we omit

If the other angles were required, they can be found by Case 1, or by theo. 1 of this sect.

RULE 3.*

Add the three sides together, and take half the sum and the differences between the half-sum and each side: then add the complements of the logarithms of the half-sum and of the difference between the half-sum and the side opposite to the angle sought, to the logarithms of the differences of the half-sum and the other sides: half their sum will be the tangent of the angle required.

Example. In the triangle *ABC*, having the side *AB* 562, *AC* 800, and *BC* 320, to find the angle *ABC*.

$AC=800$	$H=841$ Ar. Co.	7.075204
$AB=562$	$H-AC=41$ Ar. Co.	8.387216
$BC=320$	$H-AB=279$ log.	2.445604
	$H-BC=521$ log.	2.716838
Sum 1682		
	Sum	20.624862
$\frac{1}{2}$ sum $841=H$.		
	Tang. of $64°\ 2'=\frac{1}{2}$ sum	10.312431

Whose double 128° 4′ is the angle *ABC*. Whence the other angles can be easily found by theo. 1 of this section.

An example in each case of oblique-angled triangles.

1. In the triangle *ABC*, having *AB* 106, *AC* 65, and the angle *B* 31° 49′, to find the ∠s *A* and *C* and the side *BC*.

Ans. The ∠ $C=59°\ 17'$ or 120° 43′, the ∠*A* 27° 28′ or 88° 54′, and the side $BC=43.2$ or 123.2.

2. In the triangle *ABC*, having the side *AB* 2200, the ∠*A* 35°, and the ∠*B* 47° 24′, to find the sides *AC* and *BC* and the ∠*C*.

Ans. The ∠*C* 97° 36′, the side *AC* 1636, and the side *BC* 1272.

3. In the triangle *ABC*, having the side *AB* 240, *AC*

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the log. of the square of radius or 20, which is just equivalent to rejecting 20 from the sum of the four logarithms, which should be done, because for every arithmetical complement that is taken 10 must be rejected: but the Ar. Co. of the two sides containing the required angle is taken; consequently 20 should be rejected, which is equal to the log. of the square of radius.

* For the demonstration of this rule the reader is referred to Leslie's Geometry, prop. 12, p. 372.

262.7, and the angle A 46° 30′, to find the other angles and the side BC.

Ans. The $\angle C$ 60° 31′, the $\angle B$ 72° 59′, and the side BC 200.

4. In the triangle ABC, having the sides given, viz. $AB=$ 144.8, $BC=109$, and $AC=76$, it is required to find the angles by each of the three rules given to Case 4.

Ans. The least angle 29° 49′, next greater 54° 07′, and the greatest 96° 04′.

Additional exercises, with their answers.

QUESTIONS FOR EXERCISE.

1. Given the hypothenuse 108, and the angle opposite the perpendicular 25° 36′; required the base and perpendicular.

Ans. The base is 97.4, and the perpendicular 46.66.

2. Given the base 96, and its opposite angle 71° 45′; required the perpendicular and the hypothenuse.

Ans. The perpendicular is 31.66, and the hypothenuse 101.1.

3. Given the perpendicular 360, and its opposite angle 58° 20′; required the base and the hypothenuse.

Ans. The base is 222, and the hypothenuse 423.

4. Given the base 720, and the hypothenuse 980; required the angles and the perpendicular.

Ans. The angles are 47° 17′ and 42° 43′, and the perpendicular 664.8.

5. Given the perpendicular 110.3, and the hypothenuse 176.5; required the angles and the base.

Ans. The angles are 38° 41′ and 51° 19′, and the base 137.8.

6. Given the base 360, and the perpendicular 480; required the angles and the hypothenuse.

Ans. The angles are 53° 8′ and 36° 52′, and the hypothenuse 600.

7. Given one side 129, an adjacent angle 56° 30′, and the opposite angle 81° 36′; required the third angle and the remaining sides.

Ans. The third angle is 41° 54′, and the remaining sides are 108.7 and 87.08.

8. Given one side 96.5, another side 59.7, and the angle opposite the latter side 31° 30′; required the remaining angles and the third side.

Ans. This question is ambiguous, the given side opposite the given angle being less than the other given side (see Rule 1);

hence, if the angle opposite the side 96.5 be acute, it will be 57° 38′, the remaining angle 90° 52′, and the third side 114.2; but if the angle opposite the side 96.5 be obtuse, it will be 122° 22′, the remaining angle 26° 8′, and the third side 50.32.

9. Given one side 110, another side 102, and the contained angle 113° 36′; required the remaining angles and the third side.

Ans. The remaining angles are 34° 37′ and 31° 47′, and the third side is 177.5.

10. Given the three sides respectively 120.6, 125.5, and 146.7; required the angles.

Ans. The angles are 51° 53′, 54° 58′, and 73° 9′.

The student who has advanced thus far in this work with diligence and active curiosity is now prepared to study, with ease and pleasure, the following Part, which comprehends all the necessary directions for the practice of Surveying.

PART II.

THE PRACTICAL SURVEYOR'S GUIDE.

SECTION I.

Containing a particular Description of the several Instruments used in Surveying, with their respective Uses.

THE CHAIN.

The stationary distance, or merings of ground, are measured either by Gunter's chain of four poles or perches, which consists of 100 links (and this is the most natural division), or by one of 50 links, which contains two poles or perches: but because the length of a perch differs in many places, therefore the length of chains and their respective links will differ also.

The *English statute-perch* is 5½ yards, the two-pole chain is 11 yards, and the four-pole one is 22 yards; hence the length of a link in a statute-chain is 7.92 inches.

For the more ready reckoning the links of a four-pole chain, there is a large ring, or sometimes a round piece of brass, fixed at every 10 links; and at 50 links, or in the middle, there are

two large rings. In such chains as have a brass piece at every 10 links, there is the figure 1 on the first piece, 2 on the second, 3 on the third, &c. to 9. By leading therefore that end of the chain forward which has the least number next to it, he who carries the hinder end may easily determine any number of links: thus, if he has the brass piece number 8 next to him, and six links more in a distance, that distance is 86 links. After the same manner 10 may be counted for every large ring of a chain which has not brass pieces on it; and the number of links is thus readily determined.

The two-pole chain has a large ring at every 10 links, and in its middle, or at 25 links, there are two large rings; so that any number of links may be the more readily counted off, as before.

The surveyor should be careful to have his chain measured before he proceeds on business; for the rings are apt to open by frequently using it, and its length is thereby increased, so that no one can be too circumspect in this point.

In measuring a stationary distance, there is an object fixed in the extreme point of the line to be measured; this is a direction for the hinder chainman to govern the foremost one by, in order that the distance may be measured in a right line; for if the hinder chainman causes the other to cover the object, it is plain the foremost is then in a right line towards it. For this reason it is necessary to have a person that can be relied on at the hinder end of the chain, in order to keep the foremost man in a right line; and a surveyor who has no such person should chain himself. The inaccuracies of most surveys arise from bad chaining, that is, from straying out of the right line, as well as from other omissions of the hinder chainman: no person, therefore, should be admitted at the hinder end of the chain of whose abilities, in this respect, the surveyor is not previously convinced; since the success of the survey, in a great measure, depends on his care and skill.

In setting out to measure any stationary distance, the fore man of the chain carries with him ten iron pegs pointed, each about ten inches long; and when he has stretched the chain to its full length, he at the extremity thereof sticks one of those pegs perpendicularly in the ground; and leaving it there, he draws on the chain till the hinder man checks him when he arrives at that peg: the chain being again stretched, the fore man sticks down another peg, and the hind man takes up the former; and thus they proceed at every chain's length contained in the line to be measured, counting the surplus links contained between the last peg and the object at the termination of the line, as before: so that the number of pegs taken

up by the hinder chainman expresses the number of chains: to which, if the odd links be annexed, the distance line required in chains and links is obtained, which must be registered in the field-book, as will hereafter be shown.

If the distance exceeds 10, 20, 30, &c. chains, when the leader's pegs are all exhausted, the hinder chainman, at the extremity of the 10 chains, delivers him all the pegs; from whence they proceed to measure as before, till the leader's pegs are again exhausted, and the hinder chainman at the extremity of these 10 chains again delivers him the pegs, from whence they proceed to measure the whole distance line in the like manner; then it is plain, that the number of pegs the hinder chainman has being added to 10, if he had delivered all the pegs once to the leader, or to 20 if twice, or to 30 if thrice, &c., will give the number of chains in that distance; to which if the surplus links be added, the length of the stationary distance is known in chains and links.

It is customary, and indeed necessary, to have red, or other coloured cloth fixed to the top of each peg, that the hinder man at the chain may the more readily find them; otherwise, in chaining through corn, high grass, briers, rushes, &c. it would be extremely difficult to find the pegs which the leader puts down: by this means no time is lost, which otherwise must be, if no cloths are fixed to the pegs, as before.

It will be necessary here to observe, that all slant, or inclined surfaces, as sides of hills, are measured horizontally, and not on the plane or surface of the hill, and is thus effected.

Pl. 8. *fig.* 4.

Let *ABC* be a hill; the hindmost chainman is to hold the end of the chain perpendicularly over the point *A* (which he can the better effect with a plummet and line, than by letting a stone drop, which is most usual), as *d* is over *A*, while the leader puts down his peg at *e*: the eye can direct the horizontal position near enough; but if greater accuracy were required, a quadrant applied to the chain would settle that. In the same manner the rest may be chained up and down; but in going down, it is plain the leader of the chain must hold up the end thereof, and the plummet thence suspended will mark the point where he is to stick his peg. The figure is sufficient to render the whole evident, and to show that the sum of the chains will be the horizontal measure of the base of the hill: for $de=Ao$, $fg=op$, $hi=pq$, &c.; therefore $de+fg+hi$, &c.$=Ao+op+pq$, &c.

—*AC*,* the base of the hill. If a whole chain cannot be carried horizontally, half a chain, or less, may, and the sum of these half-chains, or links, will give the base, as before.

If the inclined side of the hill be the plane surface, the angle of the hill's inclination may be taken, and the slant height may be measured on the surface; and thence (by Case 1 of right-angled trigonometry) the horizontal line answering to the top may be found; and if we have the angle of inclination given on the other side, with those already given, we can find the horizontal distance across the hill, by Case 2 of oblique trigonometry.

All inclined surfaces are considered as horizontal ones; for all trees which grow upon any inclined surface do not grow perpendicular thereto, but to the plane of the horizon: thus, if *Ad*, *ef*, *gh*, &c. were trees on the side of a hill, they grow perpendicular to the horizontal base *AC*, and not to the surface *AB*: hence the base will be capable to contain as many trees as are on the surface of the hill, which is manifest from the continuation of them thereto. And this is the reason that the area of the base of a hill is considered to be equal in value to the hill itself.

Besides, the irregularities of the surfaces of hills in general are such, that they would be found impossible to be determined by the most able mathematicians. Certain regular curve surfaces have been investigated, with no small pains, by the most

* The number of chains taken down in the field-book is longer than the lines *Ao*, *op*, *pq*, &c., because the chain, being elevated above the surface of the earth (though stretched with a force at both ends), forms a curve, which approaches a right line, according as the force is more or less applied; but does not coincide with it: as, for example.—Let the chain be stretched from *d* to *e* (Pl. 8. fig. 4); it does not coincide with *de*, but forms a curve line, which must be longer than *de* or its equal *Ao*, and so is *fg* or *op* shorter than the chain, and in like manner with all the rest. And de, fg, &c. $= Ao, op$, &c. $= AC$; consequently, the number of chains, being greater than *de*, *ef*, &c. or *Ao*, *op*, &c. is greater than *AC*; therefore, the horizontal line *AC* (by surveyors in general) is made too long, therefore a deduction must be made for every chain in the field-book; the sum to be taken from *AC* may be found by making an experiment on a two-pole chain (when extended above the surface of the earth by a force at both extremities), and measuring the distance from its middle point to the middle of the right line which would join its extremities, which call *a*, and call ½ the length of the chain *b*; then $\sqrt{b^2-a^2}=\frac{1}{2}de$, or half the right line; therefore $2\sqrt{b^2-a^2}=dc$, or the right line; from whence $2b-2\sqrt{b^2-a^2}=$ the excess for every chain which is measured or taken down in the field-book: calling the number of chains *c*, then $c.\overline{2b-2\sqrt{(b^2-a^2)}}=$ the whole excess on the horizontal line *AC*. From what is here demonstrated, the practitioner will be able to find the sum to be taken from every horizontal line in surveying hills, &c.

eminent; therefore an attempt to determine in general the infinity of irregular surfaces which offer themselves to our view, to any degree of certainty, would be idle and ridiculous, and for this reason also, the horizontal area is only attempted.

Again, if the circumjacent lands of a hill be planned or mapped, it is evident we shall have a plan of the hill's base in the middle: but were it possible to put the hill's surface in lieu thereof, it would extend itself into the circumjacent lands, and render the whole a heap of confusion: so that if the surfaces of hills could be determined, no more than the base could be mapped.

Roads are usually measured by a wheel for that purpose, called the perambulator, to which there is fixed a machine, at the end whereof there is a spring, which is struck by a peg in the wheel once in every rotation; by this means the number of rotations is known; if such a wheel were 3 feet 4 inches diameter, one rotation would be $10\frac{1}{2}$ feet, which is half a plantation perch; and because 320 perches make a mile, therefore 640 rotations will be a mile also; and the machinery is so contrived that by means of a hand, which is carried round by the work, it points out the miles, quarters, and perches, or sometimes the miles, furlongs, and perches.

Or roads may be measured by a chain more accurately; for 80 four-pole, or 160 two-pole chains, or 320 perches, make a mile as before: and if roads are measured by a statute chain, it will give you the miles English, but if by a plantation chain, the miles will be Irish. Hence an English mile contains 1760, and an Irish mile 2240 yards; and because 14 half-yards is an Irish, and 11 half-yards is an English perch, therefore 11 Irish perches, or Irish miles, are equal to 14 English ones.

Since some surveys are taken by a four-pole and others by a two-pole chain, and as ground for houses is measured by feet, we will show how to reduce one to the other in the following problems.

PROBLEM I.

To reduce two-pole chains and links to four-pole ones.

If the number of chains be even, the half of them will be the four-pole ones, to which annex the given links. Thus:

1. In 16*ch*. 37*l*. of two-pole chains, how many four-pole ones? Answer 8*ch*. 37*l*.

But if the number of chains be odd, take the half of them for

chains, and add 50 to the links, and they will be four-pole chains and links. Thus:

2. In 17*ch.* 42*l.* of two-pole chains how many four-pole ones? Answer 8*ch.* 92*l.*

PROBLEM II.

To reduce four-pole chains and links to two-pole ones.

Double the chains, to which annex the links if they be less than 50; but if they exceed 50 double the chains, add one to them, and take 50 from the links, and the remainder will be the links. Thus:

	ch.	*l.*
1. In	8.	37 of four-pole chains how many two-pole ones?
	2	
	16.	37

	ch.	*l.*
2. In	8.	82 of four-pole chains how many two-pole ones?
	2.	50
	17.	32, Answer.

PROBLEM III.

To reduce four-pole chains and links to perches and decimals of a perch.

The links of a four-pole chain are decimal parts of it, each link being the hundredth part of a chain; therefore if the chain and links be multiplied by 4 (for 4 perches are a chain), the product will be the perches and decimal parts of a perch. Thus:

	ch.	*l.*
How many perches in	13.	64 of four-pole chains?
		4
Answer,	54.	56 perches.

PROBLEM IV.

To reduce two-pole chains and links to perches and decimals of a perch.

They may be reduced to four-pole ones (by prob. 1), and thence to perches and decimals (by the last); or,

If the links be multiplied by 4, carrying one to the chains when the links are, or exceed, 25; and the chains by 2, adding 1 if

occasion be; the product will be the perches and decimals of a perch. Thus:

```
         ch. l.
  1. In 17. 21 of two-pole chains how many perches?
          2. 4
         ------
Answer, 34. 84 perches.
```

```
         ch. l.
  2. In 15. 38 of two-pole chains how many perches?
          2. 4
         ------
Answer, 31. 52 perches.
```

PROBLEM V.

To reduce perches and decimals of a perch to four-pole chains and links.

Divide by 4, so as to have two decimal places in the quotient, and that will be four-pole chains and links. Thus:

In 31.52 perches how many four-pole chains and links?

```
           ch. l.
  4)31.52(7. 88, Answer.
    ----
     35
    ----
      32
    ----
```

PROBLEM VI.

To reduce perches and decimals of a perch to two-pole chains and links.

The perches may be reduced to four-pole chains (by the last), and from thence to two-pole chains (by prob. 2); or,

Divide the whole number by 2, the quotient will be chains; to the remainder annex the given decimals, and divide by 4; the last quotient will be the links. Thus:

In 31.52 perches how many two-pole chains and links?

```
            ch. l.
  2)31.52(15. 38, Answer.
    ----
    11
    ------
  4)152(38
    ------
      10
```

PROBLEM VII.

To reduce chains and links to feet and decimal parts of a foot.

If they be two-pole chains, reduce them to four-pole ones (by prob. 1): these being multiplied by the feet in a four-pole chain will give the feet and decimals of a foot. Thus:

In 17*ch.* 21*l.* of two-pole chains how many feet?

```
    ch. l.
     8. 71 of four-pole chains.
        66 feet = 1 chain.
    ------
      5226
     5226   Answer, 574ft. 10¼in.
    ------
Feet 574.86
        12
    ------
Inches 10.32
         4
    ------
      1.28
```

PROBLEM VIII.

To reduce feet and inches to chains and links.

Reduce the inches to the decimal of a foot, and annex that to the feet; that divided by the feet in a four-pole chain will give the four-pole chains and links in the quotient; these may be reduced to two-pole chains and links, if required, by prob. 2. Thus:

In 217*ft.* 9*in.* how many two-pole chains?

```
12)9.00(.75 the decimal of 9 inches.
   ----
     60
   ----
66)217.75(3.29 of four-pole chains, or 6ch. 29l.
   ----
    197
    ----
     655
    ----
      61
```

How to take a survey by the Chain *only.*

PROBLEM I.

To survey a piece of ground by going round it, and the method of taking the angles of the field by the chain only.

Pl. 6. *fig.* 6.

Let *ABCDEFG* be a piece of ground to be surveyed: beginning at the point *A*, let one chain be laid in a direct line from *A* towards *G*, where let a peg be left, as at *c*; and again the like distance from *A* in a direct line towards *B*, where another peg is also to be left, as at *d*; let the distance from *d* to *c* be measured, and placed in the field-book in the second column under the denomination of angles, in a line with station No. 1; and in the same line, under the title of distances in the third column, let the measure of the line *AB* in chains and links be inserted. Being now arrived at *B*, let one chain be laid in a direct line from *B* towards *A*, where let a peg be left, as at *f*, and again the like distance from *B* in a direct line towards *C*, where let also another peg be left, as at *e*; the distance from *e* to *f* is to be inserted in the field-book, in the second column, under angles, in a line with station No. 2; and in the same line, under the title of distances in the third column, let the measure of the line *BC*, in chains and links, be inserted: after the same manner we may proceed from *C* to *D*, and thence to *E*; but because the angle at *E*, viz. *FED*, is an external angle, after having laid one chain from *E* to *h*, and to *g*, the distance from *g* to *h* is measured and inserted in the column of angles, in a line with station No. 5, and on the side of the field-book against that station we make an asterisk, thus *, or any other mark, to signify that to be an external angle, or one measured out of the ground. Proceed we then as before from *E* to *F*, to *G*, and thence to *A*, measuring the angles and distances, and placing them as before in the field-book opposite to their respective stations: so will the field-book be completed in the manner following.

N. B.—After this manner the angles for inaccessible distances may be taken, and the method of constructing or laying them down, as well as the construction of the map, from the following field-notes, must be obvious from the method of taking them.

The form of the field-book, with the title.

A Field-Book of part of the land of Grange, in the parish of Portmarnock, barony of Coolock, and county of Dublin; being part of the estate of L. P., Esq., let to C. D., farmer. Surveyed January 30, 1782.

Taken by a four-pole chain.

Remarks.	No. Sta.	Angles. ch. l.	Distance. ch. l.
Mr. J. D.'s part of Grange . . .	1	1. 80	17. 65
	2	1. 79	18. 50
Mr. L. P.'s part of Portmarnock	3	1. 76	28. 00
Strand	4	1. 41½	20. 00
	5	1. 87½	14. 83
Widow J. G.'s part of Grange .	6	1. 14	19. 41
	7	1. 89	24. 53

Close at the first station.

Explanation of the Remarks.

Mr. J. D's part of Grange bounds or is adjacent to the surveyed land from the first to the third station; Mr. L. P's part of Portmarnock bounds it from the third to the fourth station; the strand then is the boundary from thence to the sixth; and from the sixth to the first station, the widow J. G's part of Grange is the boundary.

It is absolutely necessary to insert the persons' names, and town-lands, strands, rivers, bogs, rivulets, &c. which bound or circumscribe the land which is surveyed, for these must be expressed in the map.

In a survey of a town-land, or estate, it is sufficient to mention only the circumjacent town-lands, without the occupiers' names: but when a part only of a town-land is surveyed, then it is necessary to insert the person or persons' names who hold any particular parcel or parcels of such town-land as bound the part surveyed.

When an angle is very obtuse, as most in our present figure are, viz. the angles at *A*, *B*, *C*, *E*, and *G*, it will be best to lay a chain from the angular point, as at *A*, on each of the containing sides to *c* and to *d*; and any where nearly in the middle of the angle, as at *e*: measuring the distances *ce* and *ed*; and these may be placed for the angle in the field-book. Thus,

No. Sta.	Angle. ch. l.	ch. l.
	1. 03 1. 09	17. 65

For when an angle is very obtuse, the chord line, as *cd*, will be nearly equal to the radii *Ac* and *Ad*; so if the arc *ced* be swept, and the chord line *cd* be laid on it, it will be difficult to deter-

mine exactly that point in the arc where *cd* cuts it: but if the angle be taken in two parts, as *ce* and *ed*, the arc, and the angle thence, may be truly determined and constructed.

After the same manner any piece of ground may be surveyed by a two-pole chain.

PROBLEM II.

To take a survey of a piece of ground from any point within it, from whence all the angles can be seen, by the chain only.

PL. 6. *fig.* 6.

Let a mark be fixed at any point in the ground, as at *H*, from whence all the angles can be seen; let the measures of the lines *HA*, *HB*, *HC*, &c. be taken to every angle of the field from the point *H*; and let those be placed opposite to No. 1, 2, 3, 4, &c. in the second column of the radii: the measures of the respective lines of the mering, viz. *AB*, *BC*, *CD*, *DE*, &c. being placed in the third column of distances, will complete the field-book. Thus:

Remarks.	No.	Radii. *ch.* *l.*	Distance. *ch.* *l.*
	1	20. 00	17. 65
	2	21. 72	18. 50
	3	21. 74	28. 00
	4	25. 34	20. 00
	5	17. 20	14. 83
	6	29. 62	19. 41
	7	21. 20	24. 53

Close at the first station.

If any line of the field be inaccessible, as suppose *CD* to be, then by way of proof that the distance *CD* is true, let the measure of the angle *CHD* be taken by the line *oo*, with the chain: if this angle corresponds with its containing sides, the length of the line *DC* is truly obtained, and the whole work is truly taken.

Note.—That in setting off an angle, it is necessary to use the largest scale of equal parts, viz. that of the inch, which is diagonally divided into 100 parts, in order that the angle should be accurately laid down; or if two inches were thus divided for angles, it would be the more exact; for it is by no means necessary that the angles should be laid from the said scale with the stationary distances.

PROBLEM III.

To take a survey by the chain only, when all the angles cannot be seen from one point within.

PL. 6. *fig.* 7.

Let the ground to be surveyed be represented by 1, 2, 3, 4, &c. Since all the angles cannot be seen from one point, let us assume three points, as *A*, *B*, *C*, from whence they may be seen; at each of which let a mark be put, and the respective sides of the triangle be measured and set down in the field-book; let the distance from *A* to 1, and from *B* to 1, be measured, and these will determine the point 1; let the other lines which flow from *A*, *B*, *C*, as well as the circuit of the ground, be then measured as the figure directs; and thence the map may be easily constructed.

There are other methods which may be used; as dividing the ground into triangles, and measuring the three sides of each; or by measuring the base and perpendicular of each triangle. But this we shall speak of hereafter.

PROBLEM IV.

How to take any inaccessible distance by the chain only.

PL. 8. *fig.* 8.

Suppose *AB* to be the breadth of a river, or any other inaccessible distance, which may be required.

Let a staff or any other object be set at *B*, draw yourself backward to any convenient distance *C*, so that *B* may cover *A*; from *B*, lay off any other distance by the river's side to *E*, and complete the parallelogram *EBCD*: stand at *D*, and cause a mark to be set at *F*, in the direction of *A*; measure the distance in links from *E* to *F*, and *FB* will be also given. Wherefore *EF* : *ED* : : *FB* : *AB*. Since it is plain (from part 1, theo. 3, sect. 4, and theo. 2, sect. 4) the triangles *EFD* and *BFA* are mutually equiangular.

If part of the chain be drawn from *B* to *C*, and the other part from *B* to *E*; and if the ends at *E* and *C* be kept fast, it will be easy to turn the chain over to *D*, so as to complete a parallelogram; by reckoning off the same number of links you had in *BC*, from *E* to *D*, and pulling each part straight.

THE CIRCUMFERENTOR.

This instrument is composed of a brass circular box, about five or six inches in diameter; within which is a brass ring, divided on the top into 360 degrees, and numbered 10, 20, 30, &c. to 360: in the centre of the box is fixed a steel pin finely pointed, called a centre-pin, on which is placed a needle touched by a loadstone, which always retains the same situation; that is, it always points to the north and south points of the horizon nearly, when the instrument is horizontal, and the needle at rest.

The box is covered with a glass lid in a brass rim, to prevent the needle being disturbed by wind or rain at the time of surveying: there is also a brass lid or cover, which is laid over the former to preserve the glass in carrying the instrument.

This box is fixed by screws to a brass index or ruler of about 14 or 15 inches in length, to the ends whereof are fixed brass sights which are screwed to the index and stand perpendicular thereto: in each sight is a large and a small aperture or slit, one over the other; but these are changed, that is, if the large aperture be uppermost in the one sight, it will be lowest in the other, and so of the small ones: therefore the small aperture in one is opposite to the large one in the other, in the middle of which last there is placed a horse-hair or fine silk thread.

The instrument is then fixed on a ball and socket, by the help of which and a screw you can readily fix it horizontally in any given direction, the socket being fixed on the head of a three-legged staff, whose legs, when extended, support the instrument while it is used.

To take field-notes by the Circumferentor.

Pl. 6. *fig.* 6.

Let your instrument be fixed at any angle as *A*, your first station; and let a person stand at the next angle *B*, or cause a staff with a white sheet to be set there perpendicularly for an object to take your view to: then having placed your instrument horizontally (which is easily done by turning the box so that the ends of the needle may be equidistant from its bottom, and it traverses or plays freely) turn the flower-de-luce, or north part of the box, to your eye, and looking through the small aperture turn the index about till you cut the person or object in the next angle *B* with the horse-hair or thread of the opposite sight; the degrees then cut by the south end of the

needle will give the number to be placed in the second column of your field-book in a line with station No. 1, and expresses the number of degrees the stationary line is from the north, counting quite round with the sun.

Most needles are pointed at the south end, and have a small ring at the north: such needles are better than those which are pointed at each end, because the surveyor cannot mistake by counting to a wrong end, which error may be frequently committed in using a two-pointed needle.

Two-pointed needles have sometimes a ring, but more usually a cross towards the north end; and the south end is generally bearded towards its extremity, and sometimes not, but its arm is a naked right line from the cap at the centre.

Having taken the degrees or bearing of the first stationary line *AB*, let the line be measured, and the length thereof in chains and links be inserted in the third column of your field-book, under the title of distances, opposite to station No. 1.

It is customary, and even necessary, to cause a sod to be dug up at each station or place where you fix the instrument, to the end that if any error should arise in the field-book it may be the more readily adjusted and corrected, by trying over the former bearings and stationary distances.

Having done with your first station, set the instrument over the hole or spot where your object stood, as at *B*, for your second station, and send him forward to the next angle of the field, as at *C*; and having placed the instrument in a horizontal direction, with the sights directed to the object at *C*, and the north of the box next your eye, count your degrees to the south end of the needle, which register in your field-book in the second column opposite to station No. 2; then measure the stationary distance *BC*, which insert in the third column; and thus proceed from angle to angle, sending your object before you, till you return to the place where you began, and you will have the field-book complete; observing always to signify the parties' names who hold the contiguous lands, and the names of the town-lands, rivers, roads, swamps, lakes, &c. that bound the land you survey, as before; and this is the manner of taking field-notes by what is called fore-sights.

But the generality of mearsmen frequently set themselves in disadvantageous places, so as often to occasion two or more stations to be made where one may do, which creates much trouble and loss of time; we will therefore show how this may be remedied, by taking back-sights, thus: let your object stand at the point where you begin your survey, as at *A*; leaving him there, proceed to your next angle *B*, where fix your instru-

ment so that you may have the longest view possible towards *C*. Having set the instrument in a horizontal position, turn the south part of the box next your eye, and having cut your object at *A*, reckon the degrees to the south point of the needle, which will be the same as if they were taken from the object to the instrument, the direction of the index being the same. Let the degree be inserted in the field-book, and the stationary distance be measured and annexed thereto in its proper column; and thus proceed from station to station, leaving your object in the last point you left till you return to the first station *A*.

By this method your stations are laid out to the best advantage, and two men may do the business of three, for one of those who chain may be your object; but in fore-sights you must have an object before you, besides two chainmen.

It was said before, that a surveyor should have a person with him to carry the hinder end of the chain, on whom he can depend: this person should be expert and ready at taking offsets, as well as exact in giving a faithful return of the length of every stationary line. One who has such a person, and who uses back-sights, will be able to go over nearly double the ground he could in the same time by taking fore-sights, because of overseeing the chaining; for should he take back-sights he must be obliged, after taking his degree, to go back to the foregoing station, to oversee the chaining, and by this means to walk three times over every line, which is a labour not to be borne.

Or a back and a fore-sight may be taken at one station, thus: with the south of the box to your eye, observe from *B* the object *A*, and set down the degree in your field-book cut by the south end of the needle. Again, from *B* observe an object at *C*, with the north of the box to your eye, and set down the degree cut by the south point of the needle, so have you the bearings of the lines *AB* and *BC*; you may then set up your instrument at *D*, from whence take a back-sight to *C* and a fore-sight to *E*: thus the bearings may be taken quite round, and the stationary distances being annexed to them will complete the field-book.

But in this last method care must be taken to see that the sights have not the least cast on either side; if they have, it will destroy all: and yet with the same sights you may take a survey by fore-sights, or by back-sights only, with as great truth as if the sights were ever so erect, provided the same cast continues without any alteration; but, upon the whole, back-sights only will be found the readiest method

If your needle be pointed at each end, in taking fore-sights

you may turn the north part of the box to your eye, and count your degrees to the south part of the needle, as before; or you may turn the south of the box to your eye, and count your degrees to the north end of the needle.

But in back-sights you may turn the north of the box to your eye, and count your degrees to the north point of the needle; or you may turn the south of the box to your eye, and count your degrees to the south end of the needle.

The brass ring in the box is divided on the side into 360 degrees, thus: from the north to the east into 90, from the north to the west into 90, from the south to the east into 90, and from the south to the west into 90 degrees; so the degrees are numbered from the north to the east or west, and from the south to the east or west.

The manner of using this part of the instrument is this: having directed your sights to the object, whether fore or back, as before, observe the two cardinal points of your compass the point of the needle lies between (the north, south, east, and west being called the four cardinal points, and are graved on the bottom of the box), putting down those points together by their initial letters, and thereto annexing the number of degrees, counting from the north or south, as before, thus; if the point of your needle lies between the north and east, north and west, south and east, or south and west points in the bottom of the box, then put down *NE*, *NW*, *SE*, or *SW*, annexing thereto the number of degrees cut by the needle on the side of the ring, counting from the north or south, as before.

But if the needle point exactly to the north, south, east, or west, you are then to write down *N*, *S*, *E*, or *W*, without annexing any degree.

This is the manner of taking field-notes, whereby the content of ground may be universally determined by calculation; and they are said to be taken by the quartered compass or by the four nineties.

To find the number of degrees contained in any given angle.

Set up your instrument at the angular point, and thence direct the sights along each leg of the angle, and note down their respective bearings, as before; the difference of these bearings, if less than 180, will be the quantity of degrees contained in the given angle; but if more take it from 360, and the remainder will be the degrees contained in the given angle.

Ex. Let the angle proposed be *GAB* (pl. 6, fig. 6); place the instrument at *A*, with the flower de-luce towards you; then

direct the sights to B, and observe what degrees are cut by the south end of the needle, which let be 250°; then turning the instrument about on its stand, direct the sights to G, note again what degrees are cut by the south end of the needle, which suppose are 172°. Then $250° - 172° = 68° =$ the $\angle GAB$; but if the degrees cut should be 298° and 105°, then $298° - 105° = 193°$, which taken from 360° leaves $167° =$ the $\angle GAB$.

THE THEODOLITE.

Fig. 1. *Frontispiece.*

This instrument is a circle, commonly of brass, of ten or twelve inches in diameter, whose limb is divided into 360 degrees, and those again are subdivided into smaller parts, as the magnitude of it will admit; sometimes by equal divisions and sometimes by diagonals drawn from one concentric circle of the limb to another.

In the middle is fixed a circumferentor with a needle; but this is of little or no use, except in finding a meridian line, or the proper situation of the land.

Over the brass circle is a pair of sights, fixed to a moveable index, which turns on the centre of the instrument, and upon which the circumferentor-box is placed.

This instrument will either give the angles of the field or the bearing of every stationary distance line from the meridian, as the circumferentor and quartered compass do.

To take the angles of the field.

Pl. 6. *fig.* 6.

Lay the ends of your index to 360° and 180°; turn the whole about with the 360 from you; direct the sights from A to G, and screw the instrument fast; direct them from A to cut the object at B; the degree then cut by that end of the index which is opposite you will be the quantity of the angle GAB to place in your field-book; to which annex the measure of the line AB in chains and links; set up your instrument at B, unscrew it, and lay the ends of your index to 360 and 180; turn the whole about, with the 360 from you or 180 next you, till you cut the object at A; screw the instrument fast and direct your sights to the object at C, and the degree then cut by that end of the index which is opposite to you will be the quantity of the angle ABC

Thus proceed from station to station, still laying the index to 360, turning it from you, and observing the object at the foregoing station, screwing the instrument fast and observing the object at the following station, and counting the degrees to the opposite end of the index, will give you the quantity of each respective angle.

LEMMA.

All the angles of any polygon are equal to twice as many right angles as there are sides, less by four. Thus, all the angles A, B, C, D, E, F, G, are equal to twice as many right angles as there are sides in the figure, less by four.

Pl. 6. *fig.* 6.

Let the polygon be disposed into triangles by lines drawn from any assigned point *H* within it, as by the lines *HA*, *HB*, *HC*, &c. It is evident, then (by theo. 2, sect. 4, part 1), that the three angles of each triangle are equal to two right, and consequently that the angles in all the triangles are twice as many right ones as there are sides: but all the angles about the point *H* are equal to four right (by cor. 2, theo. 1, sect. 4); therefore the remaining angles are equal to twice as many right ones as there are sides in the figure, abating four. Q. E. D.

SCHOLIUM.

Hence we may know if the angles of a survey be truly taken; for if their sum be equal to twice as many right angles as there are stations, abating four right angles, you may conclude that the angles were truly taken, otherwise not.

If you take the bearing of any line with the circumferentor, that bearing will be the number of degrees the line is from the north; consequently the north must be a like number of degrees from the line; and thus the north, and of course the south, as well as the east and west, or the situation of the land, is obtained.

To take the bearing of each respective line from the meridian; or to perform the office of the circumferentor, or quartered compass, by the theodolite.

Set your instrument at the first station, and lay the index to 360° and 180° with the flower-de-luce of the box next 360; unscrew the instrument, and turn the whole about till the north and south points of the needle cut the north and south points in the box; then screw it fast, and the instrument is north and south, if there be no variation in the needle; but if there be, and its quantity known, it may be easily allowed.

The circumferentor-box may then be taken off.

Direct the sights to the object at the second station, and the degree cut by the opposite end of the index will be the bearing of that line from the north, and the same that the circumferentor would give.

After having measured the stationary distance, set up your instrument at the second station; unscrew it, and set either end of the index to the degree of the last line, and turning the whole about with that degree towards you, direct your sights to an object at the foregoing station, and screw the instrument fast; it will then be parallel to its former situation, and consequently north and south; direct then your sights to an object at the following station, and the degree cut by the opposite end of the index will be the bearing of that line.

In the like manner you may proceed through the whole.

If the brass circle be divided into four nineties, from 360 and 180, and the letters *N*, *S*, *E*, *W* be applied to them, the bearings may be obtained by putting down the letters the far or opposite end of the index lies between, and annexing thereto the degrees from the *N* or *S*, and this is the same as the quartered compass.

If you keep the compass-box on, to see the mutual agreement of the two instruments: after having fixed the theodolite north and south, as before, turn the index about, the north end or flower-de-luce next your eye, and count the degree to the opposite or south end of the index, and this will correspond with the degree cut by the south end of the needle.

At the second or next station, unscrew the instrument and set the south of the index to the degree of the last station; turn the whole about, with the south of the index to you, and cut the object at the foregoing station; screw the instrument fast, and with the north of the index to you, cut the object at the next following station; the degree then cut by the south of the index will correspond with the degree cut by the south end of the needle, and so through the whole.

Some theodolites have a standing pair of sights fixed at 360 and 180, besides those on the moveable index; if you would use both, look through the standing sights with the 180 next you to an object at the foregoing station: screw the instrument fast, and direct the upper sights on the moveable index to the object at the following station, and the degree cut by the opposite end of the index will give you the quantity of the angle of the field.

Two pair of sights can be of no use in finding the angles from the meridian; and inasmuch as one pair is sufficient to

find the angles of the field, the second can be of no use: besides, they obstruct the free motion of the moveable index, and therefore are rather an incumbrance than of any real use.

Some will have it that they are useful with the others for setting off a right angle in taking an offset: and surely this is as easily performed by the one pair on the moveable index: thus, if you lay the index to 360 and 180, and cut the object either in the last or following station, screw the instrument fast and turn the index to 90 and 270, and then it will be at right angles with the line. So that the small sights, at those of the circle, can be of no additional use to the instrument, and therefore should be laid aside as useless.

This instrument may be used in windy and rainy weather, as well as in mountainous and hilly grounds; for it does not require a horizontal position to find the bearing or angle, as the needle doth, and therefore is preferred to any instrument that is governed by the needle.

THE SEMICIRCLE.

This instrument, as its name imports, is a half-circle, divided from its diameter into 180 degrees, and from thence again, that is, from 0 to 360 degrees. It is generally made of brass, and is from 8 to 18 inches diameter.

On the centre there is a moveable index with sights, on which is placed a circumferentor-box, as in the theodolite.

This instrument may be used as the theodolite in all respects, but with this difference; when you are to reckon the degree to that end of the index which is off the semicircle, you may find it at the other end, reckoning the degree from 180 forwards.

THE PLANE TABLE.*

A Plane Table is an oblong of oak, or other wood, about 15 inches long and 12 broad. They are generally composed of three boards, which are easily taken asunder or put together for the convenience of carriage.

* This instrument is not much used by surveyors at present.

There is a box frame, with six joints in it, to take off and put on as occasion serves; it keeps the table together, and is likewise of use to keep down a sheet of paper which is put thereon.

The outside of the frame is divided into inches and tenths, which serve for ruling parallels or squares on the paper, or for shifting it, when occasion serves.

The inside of the frame is divided into 360 degrees, which, though unequal on it, yet are the degrees of a circle produced from its centre, or centre of the table, where there is a small hole.

The degrees are subdivided as small as their distance will admit; at every tenth degree are two numbers, one the number of degrees, the other its complement, to 360.

There is another centre-hole about one-fourth of the table's breadth from one edge, and is in the middle between the two ends. To this centre-hole on the other side of the frame, there are the divisions of a semicircle, or 180 degrees; and these again are subdivided into halves, or quarters, as the size of the instrument will admit.

That side of the frame on which the 360 degrees are, supplies the place of a theodolite, the other that of a semicircle.

There is a circumferentor-box of wood, with a paper chart at the bottom, applied to one side of the table by a dovetail joint fastened by a screw. This box (besides its rendering the plane table capable of answering the end of a circumferentor) is very useful for placing the instrument in the same position every remove.

There is a brass ruler or index, about two inches broad, with a sharp or fiducial edge, at each end of which is a sight; on the ruler are scales of equal parts, with and without diagonals, and a scale of chords; the whole is fixed on a ball and socket, and set on a three-legged staff.

To take the angles of a field by the table.

Having placed the instrument at the first station, turn it about till the north end of the needle be over the meridian, or flower-de-luce of the box, and there screw it fast. Assign any convenient point, to which apply the edge of the index, so as through the sights you may see the object in the last station, and by the edge of the index from the point draw a line. Again, turn about the index with its edge to the same point, and through the sights observe the object in the second station, and from the point, by the edge of the index, draw another line; so is the angle laid down; on that last line set off the distance to the second station, in chains and links; apply your instrument

to the second station, taking the angle as before; and after the like manner proceed till the whole is finished.

This method may be used in good weather, if the needle be well touched and play freely; but if it be in windy weather, or the needle out of order, it is better, after having taken the first angle as before, and having removed your instrument to the second station, and placed the needle over the meridian line as before, to lay the index on the last drawn line, and look backward through the sights; if you then see the object in the first station, the table is fixed right, and the needle is true; if not, turn the table about, the index lying on the last line, till through the sights you see the object in the first station: and then screw it fast, and keeping the edge of the index to the second station, direct your sights to the next; draw a line by the edge of the index, and lay off the next line; and proceed through the whole without using the needle, as you do with the theodolite.

If the sheet of paper on the table be not large enough to contain the map of the ground you survey, you must put on a clean sheet, when the other is full; and this is called shifting of paper, and is thus performed.

PL. 6. *fig.* 8.

Let *ABCD* represent the sheet of paper on the plane table, upon which the plot *E*, *F*, *G*, *H*, *I*, *K*, *L*, *M* is to be drawn: let the first station be *E*; proceed as before, from thence to *F* and to *G*; then proceeding to *H*, you find there is not room on your paper for the line *GH*, however draw as much of the line *GH* as the paper can hold, or draw it to the paper's edge. Move your instrument back to the first station *E*, and proceed the contrary way to *M* and to *L*; but in going from thence to *K*, you again find your sheet will not hold it; however draw as much of the line *LK* on the sheet as it can hold.

Take that sheet off the table, first observing the distance *oo* of the lines *GH* and *LK* by the edge of the table; take off that sheet and mark it with No. I, to signify it to be the first taken off. Having then put on another sheet, lay that distance *oo* on the contrary end of the table, and so proceed as before with the residue of the survey, from *o* to *H*, to *K*, and thence to *o*; so is your survey complete.

In the like manner you may proceed to take off and put on as many sheets as are convenient; and these may afterward be joined together with mouth glue, or fine white wafer, very thin.

If the index be fixed to the first centre, using the 360 side, it will then serve as a theodolite, and when to the second centre,

using the 180 side, it will serve as a semicircle; by either of which you may survey in rainy weather, when you cannot have paper on the table.

To measure Angles of Altitude by the Circumferentor, Theodolite, Semicircle, or Plane Table.

1. To take an angle of altitude by the circumferentor, let the glass lid be taken off, and let the instrument be turned on one side, with the stem of the ball into the notch of the socket, so that the circle may be perpendicular to the plane of the horizon; let the instrument be placed in this situation before the object, so that the top thereof may be seen through the sights; let a plummet be suspended from the centre-pin, and the object being then observed, the complement of the number of degrees comprehended between the thread of the plummet and that part of the instrument which is next your eye will give the angle of altitude required.

2. If an angle of altitude is to be taken by the theodolite, or semicircle, let a thread be run through a hole at the centre, and a plummet be suspended by it; turn the instrument on one side, by the help of the ball and notch in the socket for that purpose, so that the thread may cut 90, having 360 degrees next you; screw it fast in that position, and through the sights cut the top of the objects; and the degrees then cut by the end of the index next you are the degrees of elevation required. An angle of depression is taken the contrary way.

3. By the plane table an angle of altitude is taken in the like manner; by suspending a plummet from the centre thereof, having turned the table on one side, and fixed the index to the centre by a screw, so as to move freely, let the thread cut 90, look through the sights as before, and you have the angle of elevation, and on the contrary that of depression.

THE PROTRACTOR.

The protractor is a semicircle annexed to a scale, and is made of brass, ivory, or horn; its diameter is generally about five or six inches.

The semicircle contains three concentric semicircles, at such distances from each other that the spaces between them may contain figures.

The outward circle is numbered from the right to the left-hand, with 10, 20, 30, &c. to 180 degrees; the middlemost the same way, from 180 to 360 degrees; and the innermost from the upper edge of the scale both ways, from 10, 20, 30, &c. to 90 degrees.

It is easy to conceive that the protractor, though a semicircle, may be made to supply the place of a whole circle; for if a line be drawn, and the centre-hole of the protractor be laid on any point in that line, the upper edge of the scale corresponding with that line, the divisions on the edge of the semicircle will run from 0 to 180, from right to left: again, if it be turned the other way, or downwards, keeping the centre-hole thereof on the aforesaid point in the line, then the divisions will run from 180 to 360, and so complete an entire circle with the former semicircle.

The use of the protractor is to lay off angles, and to delineate or draw a map or plan of any ground from the field-notes; and is performed in the following manner.

To protract a field-book, when the angles are taken from the meridian.

Pl. 6. *fig.* 9.

On your paper rule lines parallel to each other, at an inch asunder (being most usual), or at any other convenient distance; on the left end of the parallels put *N* for north, and on the right *S* for south; put *E* at the top for east, and *W* at the bottom of your paper for west.

Then let the following field-book be that which is to be protracted, the bearings being taken from the meridian, whether by a circumferentor, theodolite, or semicircle, and measured with a two-pole chain.

No.	Bearing.	*ch.* *l.*
1	283½	55. 20
2	348¾	12. 36
3	317	29. 20
4	266	55. 20
5	193	40. 00
6	124	76. 00
7	63¾	87. 02

Close at the first station.

Pitch upon any convenient point on your paper for your first station, as at 1, on which lay the centre-hole of your pro-

tractor with a protracting-pin; then, if the degrees be less than 180, turn the arc of your protractor downwards, or towards the west, but if more than 180 upwards or towards the east.

Or, if the right-hand be made the north and the left the south, the west will be then up and the east down.

In this case, if the degree be less than 180, turn the arc of your protractor upwards, or towards the west; and if more, downwards, or towards the east.

By the foregoing field-book the first bearing is 283½; turn the arc of your protractor upwards, keeping the pin in the centre-hole, move the protractor so that the parallel lines may cut opposite divisions either on the ends of the scale or on the degrees, and then it is parallel. This must be always first done, before you lay off your degrees.

Then by the edge of the semicircle, keeping the protractor steady, with the pin prick the first bearing 283½, and from the centre-point, through that point or prick, draw a blank line with the pin, on which, from a scale of equal parts or from the scale's edge of the protractor, lay off the distance *55ch. 20l.*; so is that station protracted.

At the end of the first station, or at 2, which is the beginning of the second, with the pin place the centre of the protractor, turning the arc up, because the bearing of the second station is more than 180, viz. 348¾. Place your protractor parallel, as before, and, by the edge of the semicircle, with the pin prick at that degree, through which and the end of the foregoing station draw a blank line, and on it set the distance of that station.

In the like manner proceed through the whole, only observe to turn the arc of your protractor down when the degrees are less than 180.

If you lay off the stationary distances by the edge of the protractor, it is necessary to observe, that if your map is to be laid down by a scale of 40 perches to an inch, every division on the protractor's edge will be one two-pole chain; ¼ of a division will be 25 links, and ⅛ of a division will be 12½ links.

If your map is to be laid down by a scale of 20 perches to an inch, two divisions will be one two-pole chain; one division will be 25 links; ½ a division 12½ links; and ¼ of a division will be 6¼ links.

In general, if 25 links be multiplied by the number of perches to an inch the map is to be laid down by, and the product be divided by 20 (or, which is the same thing, if you cut off one and take the half), you will have the value of one division on the protractor's edge in links and parts.

EXAMPLES.

1. How many links in a division, if a map be laid down by a scale of 8 perches to an inch?

25
8
———
2|0)20|0
———
10 links, Answer.

2. How many links in a division, if a map be laid down by a scale of 10 perches to an inch?

25
10
———
2|0)25|0
———
12.5 or 12½ links, Answer.

And so of any other.

To protract a field-book taken by the angles of the field.

Note.—We here suppose the land surveyed is kept on the right-hand as you survey.

Draw a blank line with a ruler of a length greater than the diameter of the protractor; pitch upon any convenient point therein, to which apply the centre-hole of your protractor with your pin, turning the arc upwards if the angle be less than 180, and downwards if more; and observe to keep the upper edge of the scale, or 180 and 0 degrees, upon the line: then prick off the number of degrees contained in the given angle, and draw a line from the first point through the point at the degrees, upon which lay the stationary distance. Let this line be lengthened forwards and backwards, keeping your first station to the right and second to the left, and lay the centre of your protractor over the second station, with your pin turning the arc upwards if the angle be less than 180, and downwards if more; and keeping the 180 and 0 degrees on the line, prick off the number of degrees contained in the given angle, and through that point and the last station draw a line, on which lay the stationary distance; and in like manner proceed through the whole.

In all protractions, if the end of the last station falls exactly in the point you began at, the field-work and protraction are truly

taken and performed; if not, an error must have been committed in one of them: in such case, make a second protraction; if this agrees with the former, and neither meet nor close, the fault is in the field-work and not in the protraction and then a resurvey must be taken.

REMARKS.

The accuracy of geometrical and trigonometrical mensuration depends in a great degree on the exactness and perfection of the instruments made use of; if these are defective in construction or difficult in use the surveyor will either be subject to error or embarrassed with continual obstacles. If the adjustments by which they are to be rendered fit for observation be troublesome and inconvenient, they will be taken upon trust, and the instrument will be used without examination, and thus subject the surveyor to errors that he can neither account for nor correct.

In the present state of science it may be laid down as a maxim, that every instrument should be so contrived that the observer may easily examine and rectify the principal parts; for however careful the instrument-maker may be, however perfect the execution thereof, it is not possible that any instrument should long remain accurately fixed in the position in which it came out of the maker's hand, and therefore the principal parts should be moveable, to be rectified occasionally by the observer.

An enumeration of Instruments useful to a Surveyor,

Fewer or more of which will be wanted, according to the extent of his work and the accuracy required.

A case of good pocket instruments.
A pair of beam compasses.
A set of feather-edged plotting scales.
Three or four parallel rules.
A pair of proportional compasses.
A pair of triangular ditto.
A pentagraph.
A cross-staff.
A circumferentor.
A Hadley's sextant.
An artificial horizon.
A theodolite.
A surveying compass.
Measuring chains and measuring tapes.

King's surveying quadrant.
A perambulator, or measuring wheel.
A spirit-level with telescope.
Station staves used with the level.
A protractor, with or without a nonius.

To be added for County and Marine Surveying.

An astronomical quadrant, or circular instrument.
A good refracting and reflecting telescope.
A copying-glass.

For Marine Surveying.

A station-pointer.
An azimuth compass.
One or two boat compasses.

Besides these, a number of measuring rods, iron pins, or arrows, &c. will be found very convenient, and two or three offset staves, which are straight pieces of wood six feet seven inches long, and about an inch and a quarter square: they should be accurately divided into ten equal parts, each of which will be equal to one link. These are used for measuring offsets and to examine and adjust the chain.

Five or six staves, of about five feet in length and one inch and a half in diameter, the upper part painted white, the lower end shod with iron, to be struck into the ground, as marks.

Twenty or more iron arrows, ten of which are always wanted to use with the chain, to count the number of links, and preserve the direction of the chain, so that the distance measured may be *really* in a straight line.

The pocket measuring tapes, in leather boxes, are often very convenient and useful. They are made to the different lengths of one, two, three, four poles, or sixty-six feet and one hundred feet: divided on one side into feet and inches, and on the other into links of the chain. Instead of the latter are sometimes placed the centesimals of a yard, or three feet into 100 equal parts.

SECTION II.

MENSURATION OF HEIGHTS AND DISTANCES.

1st. *Of Heights.*

Pl. 5. *fig.* 18.

The instrument of least expense for taking heights, is a quadrant divided into ninety equal parts or degrees; and those may be subdivided into halves, quarters, or eighths, according to the radius, or size of the instrument: its construction will be evident by the scheme thereof.

From the centre of the quadrant let a plummet be suspended by a horse-hair, or a fine silk thread, of such a length that it may vibrate freely, near the edge of its arc; by looking along the edge *AC*, to the top of the object whose height is required, and holding it perpendicular, so that the plummet may neither swing from it, nor lie on it, the degree then cut by the hair or thread will be the angle or altitude required.

If the quadrant be fixed upon a ball and socket on the three-legged staff, and if the stem from the ball be turned into the notch of the socket, so as to bring the instrument into a perpendicular position, the angle of altitude by this means can be acquired with much greater certainty.

An angle of altitude may be also taken by any of the instruments used in surveying; as has been particularly shown in treating of their description and uses.

Most quadrants have a pair of sights fixed on the edge *AC*, with small circular holes in them; which are useful in taking the sun's altitude, requisite to be known in many astronomical cases; this is effected by letting the sun's ray, which passes through the upper sight, fall upon the hole in the lower one; and the degree then cut by the thread will be the angle of the sun's altitude; but those sights are useless for our present purpose,—for looking along the quadrant's edge to the top of the object will be sufficient as before.

To take an angle of altitude and depression with the quadrant.

Pl. 14. *fig.* 6, 7.

Let *A* be any object, as the sun, moon, or a star, or the top of a tower, hill, or other eminence: and let it be required to find the angle *ABC*, which a line drawn from the object makes above the horizontal line *BC*.

Place the centre of the quadrant in the angular point, and

move it round there as a centre, till with one eye at D, the other being shut, you perceive the object A through the sights; then will the arc GH of the quadrant, cut off by the plumb-line BH, be the measure of the angle ABC, as required.

The angle ABC of depression of any object A, below the horizontal line BC, is taken in the same manner; except that here the eye is applied to the centre, and the measure of the angle is the arc GH, on the other side of the plumb-line.*

Demonstration. In taking the angle of altitude, the angle ABG is a right angle; and because the plumb-line BH is perpendicular to the horizon, the angle CBH is also a right angle; hence if the angle CBG be taken from these equals, the remaining angles will be equal, that is $ABC=GBH$, or equal to the arc HG. Q. E. D.

In like manner, the angle GBH (in taking the angle of depression) is equal to the angle ABC.

PROBLEM I.

PL. 5. *fig.* 19.

To find the height of a perpendicular object at one station, which is on a horizontal plane.

A steeple.

Given
- The angle of altitude, 53 degrees.
- Distance from the observer to the foot of the steeple, or the base, 85 feet.
- Height of the instrument, or of the observer, 5 feet.

Required the height of the steeple.

The figure is constructed and wrought, in all respects, as Case 2 of right-angled trigonometry; only there must be a line drawn parallel to and beneath AB, of 5 feet, for the observer's height, to represent the plane upon which the object stands; to which the perpendicular must be continued, and that will be the height of the object.

Thus, AB is the base, A the angle of altitude, BC the height of the steeple from the instrument, or from the observer's eye,

* In finding the height of an object, let the observed angle be as near 45° as possible, for then a small error committed in taking it makes the least error in the computed height of the object. In taking the height of a perpendicular object, if the observed angle be 45°, the height of the object above the horizontal line is equal to the base line, and if the observed angle should be 60°, three times the square of the base line is equal to the square of the perpendicular object above the horizontal line; hence by extracting the square root of three times the square of the base or horizontal line, will give the height of the object above that line, to which add the height of the observer's eye above the horizon, and you have the true height.

if he were at the foot of it; DC the height of the steeple above the horizontal surface.

Various statings for BC, as in Case 2 of right-angled plane trigonometry.

$$\begin{array}{l} 90° \\ 53=A. \\ \hline 37=C. \\ \hline \end{array}$$

$$\begin{array}{llll} 1.\ S.C & : AB & : : S.A & : BC. \\ 37° & 85 & 53° & 112.8. \\ 2.\ R. & : AB & : : T.A & : BC. \\ 90° & 85 & 53° & 112.8. \\ 3.\ T.C & : AB & : : R. & : BC. \\ 37° & 85 & 90° & 112.8. \end{array}$$

To BC 112.8
Add DB 5. the height of the observer.

Their sum is 117.8 or 118 feet, the height of the steeple required.

PROBLEM II.

Pl. 5. fig. 20.

To find the height of a perpendicular object, on a horizontal plane, by having the length of the shadow given.

Provide a rod, or staff, whose length is given, let that be set perpendicular, by the help of a quadrant, thus; apply the side of the quadrant AC to the rod, or staff; and when the thread cuts 90°, it is then perpendicular; the same may be done by a carpenter's or mason's plumb.

Having thus set the rod or staff perpendicular, measure the length of its shadow when the sun shines, as well as the length of the shadow of the object whose height is required, and you have the proper requisites given. Thus,

ab, the length of the shadow of the staff, 15 feet.
bc, the length of the staff, 10 feet.
AB, the length of the shadow of the steeple, or object, 135 feet.
Required BC, the height of the object.

The triangles abc, ABC are similar, thus; the angle $b=B$, being both right; the lines ac, AC are parallel, being rays, or a ray of the sun; whence the angle $a=A$ (by part 3, theo. 2, sect. 4), and consequently $c=C$. The triangles, being therefore mutually equiangular, are similar (by theo. 16, sect. 4), it will be,

$ab : bc : : AB : BC.$
15 10 135 90, the steeple's height required.

The foregoing method is most to be depended however, this is mentioned for variety's sake.

PROBLEM III.

PL. 5. *fig.* 21.

To take the altitude of a perpendicular object at the foot of a hill, from the hill's side.

Turn the centre *A* of the quadrant next your eye, and look along the side *AC*, or 90 side, to the top and bottom of the object; and noting down the angles, measure the distance from the place of observation to the foot of the object. Thus,

Given { Angle to the foot of the object, $55\frac{1}{4}°$ or 55° 15′. Angle to the top of it, $31\frac{1}{4}°$ or 31° 15′ Distance to the foot of it, 250 feet.

Required the height of the object.

By Construction.

Draw an indefinite blank line *AD* at any point in which *A* makes the angles *EAB* of 55° 15′, and *EAC* of 31° 15′; lay 250 from *A* to *B*; from *B* draw the perpendicular *BE* (by prob. 7 of geometry) crossing *AC* in *C*: so will *BC* be the height of the object required.

In the triangle *ABC* there is given,

ABE the complement of *EAB* to 90°, which is 34° 45′.

CAB the difference of the given angles 24° 00′.

The side *AB* 250. Required *BC*.

This is performed as Case 2 of oblique angular trigonometry. Thus,

180 — the sum of *ABE* 34° 45′ and *CAB* 24° 00′ = *ACB* 121° 15′. Then,

S.ACB : *AB* : : *S.CAB* : *BC*.

121° 15′ 250 24° 00′ 119, the height required.

PROBLEM IV.

PL. 5. *fig.* 22.

To take the altitude of a perpendicular object on the top of a hill at one station, when the top and bottom of it can be seen from the foot of the hill.

As in prob. 1, take an angle to the top and another to the bottom of the object, and measure from the place of observation to the foot of the object, and you have all the given requisites. Thus,

A tower on a hill.

Given { Angle to the bottom 48° 30′.
Angle to the top 67° 00′.
Distance to the foot of the object 136 feet.

Required the height of the object.

By Construction.

Make the angle DAB=48° 30′, and lay 136 feet from A to B; from B let fall the perpendicular BD, and that will be the height of the hill. Produce BD upwards by a blank line. Again, at A make the angle DAC=67° 00′ by a blank line, and from C, where that crosses the perpendicular produced, draw the line CB, and that will be the height of the object required.

Let AC be drawn.

In the triangle ABC there is given,

The angle ACD the complement of DAC=23° 00′

CAB the difference between the two given angles = 18° 30′.

And the side AB 136. To find BC,

$$S.C : AB :: S.CAB : BC.$$
$$23° \quad 136 \quad 18° 30' \quad 110\tfrac{1}{4}$$

If BD were wanted it is easily obtained by the first case of right-angled plane trigonometry.

PROBLEM V.

Pl. 5. *fig.* 23.

To take an inaccessible perpendicular altitude on a horizontal plane.

This is done at two stations. Thus,

Let DC be a tower which cannot be approached, by means of a moat or ditch, nearer than B; at B take an angle of altitude to C: measure any convenient distance backward to A, which note down; at A take another angle to C; so have you the given requisites. Thus,

Given { First angle 55° 00′.
Stationary distance 87 feet.
Second angle 37° 00′.

The height of the tower CD is required.

By Construction.

Upon an indefinite blank line lay off the stationary distance 87 from A to B; from B set off your first, and from A your

second angle; from C, the point of intersection of the lines which form these angles, let fall the perpendicular CD; and that will be the height of the object required.

The external angle CBD of the triangle ABC is equal to the two internal opposite ones A and ACB (by theo. 4, sect. 4): wherefore if one of the internal opposite angles be taken from the external angle, the remainder will be the other internal opposite one. Thus,

$$CBD\ 55° - A\ 37° = ACB\ 18°.$$

Therefore, in the triangle ABC we have the angles A and ACB with the side AB given, to find BC.

$$S.ACB : AB :: S.A : BC.$$
$$18° \quad 87 \quad 37° \quad 169.4.$$

Having found BC, we have in the triangle BCD the angle CBD 55°; consequently BCD 35°, and BC 169.4, to find DC.

This is performed by the first case of right-angled trigonometry three several ways. Thus:

1. $R : BC :: S.CBD : DC.$
   90° 169.4 55° 138.8,
   the height required.
2. Sec. $CBD : BC :: T.CBD : DC.$
   55° 169.4 55° 138.8,
   the height required.
3. Sec. $BCD : BC :: R : CD.$
   35° 169.4 90° 138.8,
   the height required.

If BD, the breadth of the moat, were required, it may also be found by three different statings, as in the first case of right-angled plane trigonometry.

PROBLEM VI.

Pl. 5. *fig.* 24.

Let BC, a maypole, whose height is 100 feet, be broken at D, the upper part of which, DC, falls upon a horizontal plane, so that its extremity C is 34 feet from the bottom or foot of the pole.

Required the segments BD and DC.

By Construction.

Lay 34 feet from A to B; on B erect the perpendicular BC of 100 feet, and draw AC; bisect AC (by prob. 4, geom.)

with the perpendicular line *EF*; and from *D*, where it cuts the perpendicular *BC*, draw *AD*, which will be the upper segment, and *DB* will be the lower.

By cor. to lemma preceding theo. 7, geom., $AD=DC$; and (by the lemma) the angle $C=CAD$.

In the triangle *ABC* find *C*, as in Case 6 of right-angled trigonometry. Thus,

1. $BC : R :: AB : T.C=CAD.$
   100 90° 34 18° 47′.

By theo. 4, geom. The external angle $ADB=37° 34′$, or to twice the angle *C*; *i. e.* to *C* and *CAD*.

Then in the triangle *ABD* there is *ADB* 37° 34′, therefore also its complement *DAB* 52° 26′ and *AB* 34 given, to find *AD* and *BD*.

By the second case of right-angled trigonometry:

2. $S.ADB : AB :: R : AD$ or *DC*.
   37° 34′ 34 90° 55.77.

   $BC-DC=BD.$
   $100-55.77=44.23$, required.

These may be had from other statings, as in the second case aforesaid.

PROBLEM VII.

Pl. 5. *fig.* 26.

To take the altitude of a perpendicular object on a hill, from a plane beneath it.

This is done at two stations. Thus,

Let the height *DC* of a windmill on a hill be required.

From any part of the plane whence the foot of the object can be seen, let angles be taken to the foot and top; measure thence any convenient distance towards the object, and at the end thereof take another angle to the top, and you have the proper requisites. Thus,

First station. Angle to the foot *DAB* 21° 00′.
Angle to the top *CAB* 35° 00′.
Stationary distance *AB* 104 feet.

Second station. Angle to the top 48° 30′.
DC required.

By Construction.

On an indefinite blank line lay the stationary distance *AB* 104 feet; from *A* set off the second, and from *B* the third given angle; and from the intersecting point *C* of the line formed by

them let fall the perpendicular CE; from A set off the first angle, and the line formed by it will determine the point D. Thus have we the height of the hill, as well as that of the windmill.

The angle $CBE-A=ACB$, as in the last prob.

In the triangle ABC find AC thus,

$S.ACB : AB :: S.ABC$ (or sup. of CBE) $: AC$.
$13° 30' : 104 :: 131° 30' : 333.6$.

The angle $CAE-DAE=CAD$.
The angle $ACD=AED+EAD$, by theo. 4.

In the triangle CAD find CD thus,

$S.ADC : AC :: S.CAD : DC$.
$111° : 333.6 :: 14° : 86.46$ required.

CE, BE, or DE may be found by other various statings as set forth in the first and second cases of right-angled trigonometry.

PROBLEM VIII.

Pl. 5. fig. 26.

To find the length of an object that stands obliquely on the top of a hill, from a plane beneath.

Let CD be a tree whose length is required.

This is done at two stations.

Make a station at B, from whence take an angle to the foot and another to the top of the tree; measure any convenient distance backward to A, from whence also let an angle be taken to the foot and another to the top, and you have the requisites given. Thus:

First station.	Angle to the foot $EBD=36° 30'$.
	Angle to the top $EBC=44° 30'$.
	Stationary distance $AB=104$ feet.
Second station.	Angle to the foot $EAD=24° 30'$.
	Angle to the top $EAC=32° 00'$.

Let DC and DE be required.

The geometrical constructions of this and the next problem are omitted, as what has been already said, and the figures, are looked upon as sufficient helps.

$EBC-A=ACB$, or $44° 30'-32°=12° 30'$, as before.

In the triangle ABC find BC thus,

1. $S.ACB : AB :: S.A : BC$.
$12° 30' \quad 104 \quad 32° \quad 254.7$.

$EBD-EAD=ADB$, or $36° 30'-24° 30'=12° 00'$.

In the triangle ADB find DB thus,

2. $S.ADB : AB :: S.DAB : DB.$
   12° 00′ 104 24° 30′ 207.4.

$CBE—DBE=CBD$, or 44° 30′—36° 30′=8° 00′.

In the triangle CBD there is given CB 254.7, DB 207.4, and the angle CBD 8° 00′, to find DC.

This is performed as Case 3 of oblique-angled trigonometry. Thus,

3. $BC+BD : BC—BD :: T.$ of $\frac{1}{2}(BDC+BCD) : T.$ of
   462.1 47.3 86° 00′
$\frac{1}{2}(BDC—BCD).$
   55° 40′.

86° 00′+55° 40=141° 40′=BDC.
86° 00′—55° 40′= 30° 20′=BCD.

4. $S.BCD : BD :: S.CBD : DC.$
   30° 20′ 207.4 8° 00′ 57.15, length of the tree.

To find DE in the triangle DBE, say

$R. : BD :: S.DBE : DE.$
90° 207.4 36° 30′ 123.4, height of the hill.

PROBLEM IX.

To find the height of an inaccessible object CD, on a hill BC, from ground that is not horizontal.

Pl. 6. *fig.* 1.

From any two points, as G and A, whose distance GA is measured, and therefore given; let the angles HGD, BAD, BAC, and EAG be taken; because GH is parallel to EA (by part 2, theo. 3, geom.), the angle $HGA=EAG$; therefore $EAG+HGD=AGD$: and (by cor. 1, theo. 1, geom.) 180 — the sum of EAG and $BAD=GAD$; and, by cor. 1, theo. 5, geom., 180 — the sum of the angles AGD and $GAD=GDA$: thus we have the angles of the triangle AGD and the side AG given; thence (by Case 2 of obl. ang. trig.) AD may be easily found. The angle $DAB—CAB=DAC$, and 90°—$BAD=ADC$, and 180°—the sum of DAC and $ADC=ACD$: so have we the several angles of the triangle ACD given, and the side AD; whence (by Case 2 of obl. trig.) CD may be easily found. We may also find AC, which with the angle BAC will give CB the height of the hill.

The solutions of the several problems in heights and distances by Gunter's scale are omitted; because every particular stating has been already shown by it, in Trigonometry.

2d. *Of Distances.*

The principal instruments used in surveying will give the angles or bearings of lines; which was particularly shown when we treated of them.

PROBLEM I.

Pl. 6. *fig.* 2.

Let A and B be two houses on one side of a river, whose distance asunder is 293 perches: there is a tower at C on the other side of the river, that makes an angle at A with the line AB of 53° 20′, and another at B with the line BA of 66° 20′; required the distance of the tower from each house, viz. AC and BC.

This is performed as Case 2 of oblique-angled trigonometry, thus,

1. $S.C : AB :: S.A : BC.$
   60° 20′ 293 53° 20′ 270.5.
2. $S.C : AB :: S.B : AC.$
   60° 20′ 293 66° 20′ 308.8.

PROBLEM II.

Pl. 6. *fig.* 11.

Let B and C be two houses whose direct distance asunder, BC, is inaccessible: however, it is known that a house at A is 252 perches from B, and 230 from C, and that the angle BAC is found to be 70°. What is the distance BC between the two houses?

This is performed as Case 3 of oblique-angled trigonometry, thus,

1. $AB+AC : AB-AC :: T.$ of $\frac{1}{2}(C+B) : T.$ of $\frac{1}{2}(C-B).$
   482 22 55° 00′ 3° 44′.

$55°+3° 44' = 58° 44' = C.$ $55°-3° 44' = 51° 16' = B.$

2. $S.C : AB :: S.A : BC.$
   58° 44′ 252 70° 277.

PROBLEM III.

Pl. 6. *fig.* 3.

Suppose ABC a triangular piece of ground, which by an old survey we find to be thus; AB 260, AC 160, BC 150 perches,

the mearing lines *AC* and *BC* are destroyed or ploughed down, and the line *AB* only remaining. What angles must be set off at *A* and *B* to run new mearings by exactly where the old ones were?

This is performed as in Case 4 of oblique-angled trigonometry, thus,

1. $AB : AC+BC :: AC-BC : AD-DB.$
   260 310 10 11.92.
   $130+5.96=135.96=AD.$
   $130-5.96=124.04=DB.$
2. $AD : R :: AC :$ sec. $A.$
   136 90° 160 31° 47′.
3. $BC : S.A :: AC : S.B.$
   150 31° 47′ 160 34° 10′.

PROBLEM IV.

PL. 6. *fig.* 4.

Let *D* and *C* be two trees in a bog, to which you can have no nearer access than at *A* and *B*; there is given *DAB* 100°, *CAB* 36° 30′, *CBA* 121°, *DBA* 49°, and the line *AB* 113 perches. Required the distance of the trees *DC*.

180° — the sum of *DBA* and $DAB=ADB=31°$.
180° — the sum of *CAB* and $CBA=ACB=22° 30′$.

In the triangle *ABD*, find *DB* thus,

1. $S.ADB : AB :: S.DAB : DB.$
   31° 113 100° 216.

And in the triangle *ABC*, find *BC* thus,

2. $S.ACB : AB :: S.CAB : BC.$
   22° 30′ 113 36° 30′ 175.6.

In the triangle *DBC*, you have $DBC=ABC-ABD=72°$, likewise the sides *BD*, *BC* as before found, given, to find *DC*.

3. $BD+BC : BD-BC :: T.$ of $\frac{1}{2}(DCB+CDB) : T.$
   391.6 40.4 54°
of $\frac{1}{2}(DCB-CDB).$
   8° 05′.

$54°+8° 05′=62° 05′=DCB.$
$54°-8° 05′=45° 55′=CDB.$

4. $S.CDB : BC :: S.DBC : DC.$
   45° 55′ 175.6 72° 232.5.

LEMMA.

Pl. 6. *fig.* 10.

If from a point C of a triangle ABC, inscribed in a circle, there be a perpendicular CD let fall upon the opposite side AB, that perpendicular is to one of the sides, including the angle, as the other side, including the angle, is to the diameter of the circle, i. e. $DC : AC :: CB : CE$.

Let the diameter CE be drawn, and join EB; it is plain, the angle $CEB = CAB$ (by cor. 2, theo. 7, geom.), and CBE is a right angle (by cor. 5, theo. 7, geom.), and $= ADC$: whence $ECB = ACD$. The triangles CEB, CAD are therefore mutually equiangular, and (by theo. 16, geom.) $DC : AC :: CB : CE$, or $DC : CB :: AC : CE$. Q. E. D.

PROBLEM V.

Pl. 6. *fig.* 5.

Let three gentlemen's seats A, B, C be situate in a triangular form: there is given, AB 2.5 miles, AC 2.3, and BC 2. It is required to build a church at E, that shall be equidistant from the seats A, B, C. What distance must it be from each seat, and by what angle may the place of it be found?

By Construction.

By prob. 15, geom., find the centre of a circle that will pass through the points A, B, C, and that will be the place of the church; the measure of which, to any of these points, is the answer for the distance: draw a line from any of the three points to the centre, and the angle it makes with either of the sides that contain the angle it was drawn to; that angle laid off by the direction of an instrument, on the ground, and the distance before found, being ranged thereon, will give the place of the church required.

By Calculation.

$$1.\ AB : AC+BC :: AC-BC : AD-DB.$$
$$2.5 \qquad 4.3 \qquad .3 \qquad .516.$$
$$1.25+.258=1.508=AD.$$

By cor. 2, theo. 14, geom., the square root of the difference of the squares of the hypothenuse AC, and given leg AD, will give DC.

That is, $5.29-2.274064=3.015936$.

Its square root is $1.736 = CD$.

Then, by the preceding lemma,

$$2.\ CD : AC :: CB : \text{the diameter.}$$
$$1.736 \quad 2.3 \quad 2 \quad 2.65.$$

the half of which, viz. 1.325, is the semidiameter, or distance of the church from each seat, that is, AE, CE, BE.

From the centre E let fall a perpendicular upon any of the sides as EF, and it will bisect it in F (by theo. 8, geom.).

Wherefore, $AF = CF = \frac{1}{2}AC = 1.15$.

In the right-angled triangle AFE you have AF 1.15, and AE the radius 1.325 given, to find FAE. Thus:

$$3.\ AF : R :: AE : \text{sec. } FAE.$$
$$1.15 \quad 90^\circ \quad 1.325 \quad 29^\circ\ 47'.$$

Wherefore, directing an instrument to make an angle of 29° 47′ with the line AC, and measuring 1.325 on that line of direction, will give the place of the church, or the centre of a circle that will pass through A, B, and C.

The above angle FAE may be had without a secant, as before. Thus:

$$AE : R :: AF : S.AEF.$$
$$1.325 \quad 90^\circ \quad 1.15 \quad 60^\circ\ 13'.$$

Its complement 29° 47′ will give FAE, as before.

PRACTICAL QUESTIONS.

Ex. 1. At 170 feet distance from the bottom of a tower the angle of its elevation was found to be 52° 30′. Required the altitude of the tower. Ans. 221.55 feet.

Ex. 2. From the top of a tower, by the seaside, of 14.3 feet high, it was observed that the angle of depression of a ship's bottom, then at anchor, measured 35°. What then was the ship's distance from the bottom of the wall?

Ans. 204.22 feet.

Ex. 3. From a window near the bottom of a house which seemed to be on a level with the bottom of a steeple, I took the angle of elevation of the top of the steeple, equal 40°; then from another window, 18 feet directly above the former, the like angle was 37° 30′. What then is the height and distance of the steeple?

Ans. $\begin{cases} \text{height} & 57.26. \\ \text{distance} & 150.50. \end{cases}$

Ex. 4. Wanting to know the height of an inaccessible tower at the least distance from it, on the same horizontal plane, I

took its angle of elevation, equal to 58°; then going 300 feet directly from it, found the angle there to be only 32°. Required its height and my distance from it at the first station.

Ans. $\begin{cases} \text{height } 307.53. \\ \text{distance } 192.15. \end{cases}$

Ex. 5. Being on the side of a river, and wanting to know the distance to a house which was seen on the other side, I measured out for a base 400 yards in a right line by the side of the river, and found that the two angles, one at each end of this line, subtended by the other end and the house, were 68° 2′ and 73° 15′. What then was the distance between each station and the house?

Ans. $\left\{ \begin{matrix} 593.08 \\ 612.38 \end{matrix} \right\}$ yards.

Ex. 6. Wanting to know the breadth of a river, I measured a base of 500 yards in a straight line close by one side of it, and at each end of this line I found the angles subtended by the other end and a tree close to the bank on the other side of the river to be 53° and 73° 15′. What then was the perpendicular breadth of the river? Ans. 529.48 yards.

Ex. 7. Two ships of war, intending to cannonade a fort, are, by the shallowness of the water, kept so far from it that they suspect their guns cannot reach it with effect. In order therefore to measure the distance, they separate from each other a quarter of a mile, or 440 yards; then each ship observes and measures the angle which the other ship and the fort subtend, which angles are 83° 45′ and 85° 15′. What then is the distance between each ship and the fort?

Ans. $\left\{ \begin{matrix} 2292.26 \\ 2298.05 \end{matrix} \right\}$ yards.

Ex. 8. A point of land was observed by a ship at sea to bear east by south; and after sailing north-east 12 miles, it was found to bear south-east by east. It is required to determine the place of that headland, and the ship's distance from it at the last observation. Ans. 26.0728 miles.

Ex. 9. If the height of the mountain called the Peak of Teneriffe be $2\frac{1}{3}$ miles, as it is very nearly, and the angle taken at the top of it, as formed between a plumb-line and a line conceived to touch the earth in the horizon, or farthest visible point, be 88° 2′; it is required from these measures to determine the magnitude of the whole earth, and the utmost distance that can be seen on its surface from the top of the mountain, supposing the form of the earth to be perfectly globular.

Ans. $\left\{ \begin{matrix} \text{distance } 135.943 \\ \text{diameter } 7916 \end{matrix} \right\}$ miles.

Ex. 10. Wanting to know the extent of a piece of water, or distance between two headlands, I measured from each of them to a certain point island, and found the two distances to be 735 yards and 840 yards; also the horizontal angle subtended between these two lines was 55° 40′. What then was the distance required? Ans. 741.2 yards.

Ex. 11. Wanting to know the distance between a house and a mill which were seen at a distance on the other side of a river, I measured a base line along the side where I was of 600 yards, and at each end of it took the angles subtended by the other end and the house and mill, which were as follows, viz. at one end the angles were 58° 20′ and 95° 20′, and at the other end the like angles were 53° 30′ and 98° 45′. What then was the distance between the house and mill?

Ans. 962.5866 yards.

Ex. 12.* Wanting to know my distance from an inaccessible object 0 on the other side of a river, and having no instrument for taking angles, but only a chain or cord for measuring distances; from each of two stations, *A* and *B*, which were taken at 500 yards asunder, I measured, in a direct line from the object 0, 100 yards, viz. *AC* and *BD*, each equal 100 yards; also the diagonal *AD* measured 550 yards, and the diagonal *BC* 560. What then was the distance of the object 0 from each station *A* and *B*? Ans. $\left\{ \begin{array}{l} A\ 0\ \ 526.81. \\ B\ 0\ \ 500.47. \end{array} \right\}$ yards.

SECTION III.

MENSURATION OF AREAS,

OR THE VARIOUS METHODS OF CALCULATING THE SUPERFICIAL CONTENTS OF ANY FIELD.

Definition.

THE area or contents of any plane surface in perches is the number of square perches which that surface contains.

* These practical examples are taken from Hutton's Mathematics, vol. ii. seventh London edition.

PL. 7. *fig.* 1.

Let *ABCD* represent a rectangular parallelogram, or oblong; let the side *AB* or *DC* contain eight equal parts, and the side *AD* or *BC* three of such parts; let the line *AB* be moved in the direction of *AD* till it has come to *EF*, where *AE* or *BF* (the distance of it from its first situation) may be equal to one of the equal parts. Here it is evident that the generated oblong *ABEF* will contain as many squares as the side *AB* contains equal parts, which are eight; each square having for its side one of the equal parts into which *AB* or *AD* is divided. Again, let *AB* move on till it comes to *GH*, so as *GE* or *HF* may be equal to *AE* or *BF*; then it is plain that the oblong *AGHB* will contain twice as many squares as the side *AB* contains equal parts. After the same manner it will appear that the oblong *ADCB* will contain three times as many squares as the side *AB* contains equal parts; and, in general, that every rectangular parallelogram, whether square or oblong, contains as many squares as the product of the number of equal parts in the base multiplied into the number of the same equal parts in the height contains units, each square having for its side one of the equal parts.

Hence arises the solution of the following problems.

PROBLEM I.

To find the contents of a square piece of ground.

1. Multiply the base in perches into the perpendicular in perches, the product will be the contents in perches; and because 160 perches make an acre, it must thence follow that

Any area, or contents in perches, being divided by 160, will give the contents in acres; the remaining perches, if more than 40, being divided by 40, will give the roods, and the last remainder, if any, will be perches.

Or thus:

2. Square the side in four-pole chains and links, and the product will be square four-pole chains and links: divide this by 10, or cut off one more than the decimals, which are five in all, from the right towards the left: the figures on the left are acres; because 10 square four-pole chains make an acre, and the remaining figures on the right are decimal parts of an acre. Multiply the five figures to the right by four, cutting five figures

from the product, and if any figure be to the left of them it is a rood, or roods; multiply the last cut off figures by 40, cutting off five, or (which is the same thing) by 4, cutting off four; and the remaining figures to the left, if any, are perches.

1. The first part is plain, from considering that a piece of ground in a square form, whose side is a perch, must contain a perch of ground; and that 40 such perches make a rood, and four roods an acre; or, which is the same thing, that 160 square perches make an acre, as before.

2. A square four-pole chain (that is, a piece of ground four poles or perches every way) must contain 160 square perches; and 160 perches make an acre; therefore 10 times 16 perches, or 10 square four-pole chains, make an acre.

Note.—The chains given or required, in any of the following problems, are supposed to be two-pole chains, that chain being most commonly used; but they must be reduced to four-pole chains or perches for calculation, because the links will not operate with them as decimals.

EXAMPLES.

PL. 1. *fig.* 17.

Let *ABCD* be a square field, whose side is 14*ch.* 29*l.*; required the contents in acres.

By problem 4, section 1, part 2, 14*ch.* 29*l.* are equal to

```
        29.16  perches
        29.16
        -----
        17496
        2916
       26244
       5832
     ----------  A. R. P.
  160)850.3056(  5  1  10, contents.
      ---
     40)50(1 rood.
        --
        10 perches.
```

Or thus:

14*ch.* 29*l.* are equal to 7*ch.* 29*l.* of four-pole chains, by problem 1, section 1, part 2.

```
                 ch. l.
                  7.29
                  7.29
                 ------
                  6561
                 1458
                5103
                -------                A. R. P.
Acres 5|31441 contents, as before,  5  1  10.
                   4
                -------
 Rood 1|25764
                  40
                -------
Perches 10|30560
                -------
```

It is required to lay down a map of this piece of ground, by a scale of twenty perches to an inch.

Take 29.16, the perches of the given side, from the small diagonal on the common surveying scale, where twenty small, or two of the large divisions are an inch: make a square whose side is that length (by prob. 9, geom.), and it is done.

PROBLEM II.

To find the side of a square whose contents are given.

Extract the square root of the given contents in perches, and you have the side in perches, and consequently in chains.

EXAMPLE.

It is required to lay out a square piece of ground which shall contain 12A. 3R. 16P. Required the number of chains in each side of the square; and to lay down a map of it by a scale of 40 perches to an inch.

```
A.  R.  P.
12  3  16
 4
----
51
 40
----
2056
```

2056(45.34+ perches =22ch. 33¼l. by prob 6 sect. 1, part 2.

85)456

903)3100

9064)39100 &c.

To draw the map.

From a scale where 4 of the large or 40 of the small divisions are an inch, take 45.34 the perches of the side, of which make a square.

PROBLEM III.

To find the contents of an oblong piece of ground.

Multiply the length by the breadth, for the contents.

EXAMPLE.

Pl. 1. *fig.* 3.

Let *ABCD* be an oblong piece of ground, whose length *AB* is 14*ch.* 25*l.* and breadth 8*ch.* 37*l.* Required the contents in acres, and also to lay down a map of it, by a scale of 20 perches to an inch.

ch. l. perches.
14.25=29.00 } By prob. 4, sect. 1, part 2.
8.37=17.48 }

15732
3496

A. R. P.
160)506.9200(3 0 27 contents.

26 perches, or near 27.

Or thus:
four-pole ch.
ch. l. ch. l.
14.25=7.25 } By prob. 1, sect. 1, part 2.
8.37=4.37 }

5075
2175
2900

31682

```
Acres 3|16825
         4
   -------
Rood  |67300
         4
   -------
Perches 26|9200
   -------
```

To draw the map.

Make an oblong (by schol. to prob. 9, geom.) whose length, from a scale of 20 to an inch, may be 29 perches, and breadth 17.48 perches.

PROBLEM IV.

The contents of an oblong piece of ground and one side given, to find the other.

Divide the contents in perches by the given side in perches, the quotient is the side required in perches; and thence it may be easily reduced to chains.

EXAMPLE.

There is a ditch 14*ch.* 25*l.* long, by the side of which it is required to lay out an oblong piece of ground which shall contain 3A. 0R. 27P. What breadth must be laid off at each end of the ditch to enclose the 3A. 0R. 27P.?

```
    A. R. P.
    3  0  27
    4
   --
   12
   40
   ---  perch. ch. l.
29)507(17.48=8 37, breadth.
   ---
   217
   ---
    140
    ---
     240
     ---
       8
     ---
```

The map is constructed like the last.

PROBLEM V.

To find the contents of a piece of ground in form of an oblique angular parallelogram, or of a rhombus or rhomboides.

RULE I.

Multiply the base into the perpendicular height. The reason is plain from theo. 13, geom.

EXAMPLE.

PL. 7. *fig.* 2.

Let *ABCD* be a piece of ground in form of a rhombus, whose base *AB* is 22 chains, and perpendicular *DE* or *FC* 20 chains. Required the contents.

$$\begin{array}{l} \textit{ch.} \\ 22=11.0 \\ 20=10.0 \end{array}\Big\}\text{ four-pole chains.}$$

Acres 11|0

$$\begin{array}{l} \textit{ch.} \quad \text{Or,} \\ 22=44 \\ 20=40 \end{array}\Big\}\text{ perches.}$$

160)1760(11 acres.

160

0

The converse of this is done by prob. 4, and the map is drawn by laying off the perpendicular on that part of the base from whence it was taken, joining the extremity thereof to that of the base by a right line, and thence completing the parallelogram.

RULE II.

As rad. (viz. S. of 90°, or tang. of 45°)
Is to the sine of any angle of a parallelogram,
So is the product of the sides including the angle :
To the area of the parallelogram.

That is, $DA \times AB \times$ nat. sine of the angle A = the area.* Pl. 7, fig. 2.

* Demonstration. For, having drawn the perpendicular *DE* the area by the first rule is $AB \times DE$; but as radius 1 ($S. \angle E$) : $S. \angle A$: : AD :

EXAMPLE.

How many acres are in a rhomboides whose less angle is 30° and the including sides 25.35 and 10.4 four-pole chains?

Ans. 13A. 0R. 29.12P.

(Rad.) 1 : .500000 (Nat. S. of 30°) : : 263.640 (=25.35× 10.4) : 131.82 = the area in four-pole chains; which divided by 10 (because 10 square chains are an acre) gives 13.182 acres, or 13A. 0R. 29.12P.

Note.—Because the angle of a square and rectangle are each 90°, whose sine is 1, this rule for them is the same as the first.

PROBLEM VI.

To find the contents of a triangular piece of ground.

Multiply the base by half the perpendicular, or the perpendicular by half the base; or take half the product of the base into the perpendicular.

The reason of this is plain from cor. 2, theo. 12, geom.

EXAMPLE.

PL. 1. *fig.* 16.

Let *ABC* be a triangular piece of ground whose longest side or base *BC* is 24*ch.* 38*l.*, and perpendicular *AD*, let fall from the opposite angle, is 13*ch.* 28*l.* Required the contents.

```
           ch. l.   ch. l.
1.  Base 24.38=12.38 } four-pole chains.
      ½ perp.   3.39 }
               -----
               11142
               3714
              3714
              ------
      Acres 4|19682
                  4
              ------
       Rood  |78728
                 40
              ------
   Perches 31|49120
```

Contents, 4A. 0R. 31P.

DE=*S.*∠*A*×*DA*; therefore, *DE*×*AB*=*AB*×*S.*∠*A*×*DA*=the area, or, 1 : *S.*∠*A* : : *DA*×*AB* : *S.*∠*A*×*DA*×*AB*= the area of the parallelogram. Q. E. D.

ch. l. *ch. l.*

Perp. 13.28=6.78 } four-pole chains, by prob. 1, sect. 1, part 2
½ perp. 6.39=3.39 }

Or, 2dly. Perp. 6.78 of four-pole chains.
½ base 6.19

6102
678
4068

4|19682=4A. 0R. 31P.

ch. l.

Or, 3dly. Base 12.38 four-pole chains.
Perp. 6.78

9904
8666
7428

83.9364

Its half =4|19682=4A. 0R. 31P.

Or the base and perpendicular may be reduced to perches, and the contents may thence be obtained, thus:

ch. l. *perches.*

Perp. 13.28=27.12 } By prob. 4, sect. 1, part 2.

Half the perp. 13.56 }

perches. *ch. l.*

1. Base 49.52=24.38
½ perp. 13.56

29712
24760
14856
4952

160)671.4912(4A. 0R. 31P.

31

```
                 perches.
2. Perp.           27.12
   Half-base       24.76
                  ------
                   16272
                  18984
                 10848
                 5424
                ------
                671.4912=4A. 0R. 31P.
```

But square perches may be reduced to acres, &c. rather more commodiously by dividing by 40 and 4, than by 160; thus,

```
4|0)67|1
--------
4)16. 31
--------
A. 4. 0. 31
--------
```

```
                perches.
3.  Base         49.52
    Perp.        27.12
                ------
                  9904
                 4952
                34664
                9904
               -------
               1342.9824
               -------
               671.4912=4A. 0R. 31P.
```

The map may be readily drawn, having the distance from either end of the base to the perpendicular given; as may be evident from the figure.

PROBLEM VII.

The contents of a triangular piece of ground and the base given, to find the perpendicular.

Divide the contents in perches by half the base in perches, and the quotient will give you the perpendicular in perches, and so in chains.

EXAMPLE.

Pl. 1. *fig.* 16.

Let *BC* be a ditch, whose length is 24*ch.* 40*l.*, by which it is required to lay out a triangular piece of ground, whose contents shall be 4A. 1R. 10P. Required the perpendicular.

ch. l. Perches.
Base 24.40=49.6
Half the base=24.8

A. R. P.
4 1 10
4
———
17
40
——— *Perches.*
24.8)690(27.82
———
1940
———
2040
———
560
———
64
——— *Perches. ch. l.*
Answer, perp. 27.82=13.45

This perpendicular being laid on any part of the base, and lines run from its extremity to the ends of the base, will lay out the triangle (by cor. to theo. 13, geom.) so that the perpendicular may be set on that part of the base which is most convenient and agreeable to the parties concerned.

PRACTICAL QUESTIONS.

Ex. 1. What is the area of a parallelogram whose length is 12.25 and its height 8.5 four-pole chains?

Ans. 10A. 1R. 26P.

Ex. 2. What is the area of a square whose side is 70.25 two-pole chains? Ans. 124A. 1R. 1P.

Ex. 3. What is the area of a rhombus whose side is 60 perches, and its height 45 perches? Ans. 16A. 3R. 20P.

Ex. 4. What is the area of a rhomboides whose less angle is 40° and the including sides 80 and 25 four-pole chains?

Ans. 128A. 2R. 9P.

Ex. 5. What is the area of a triangle whose base is 12 and its perpendicular height 6 two-pole chains?

Ans. 1A. 3R. 8P.

LEMMA.

Pl. 8. *fig.* 9.

If from half the sum of the sides of any plane triangle ABC each particular side be taken, and if the half-sum and the three remainders be multiplied continually into each other, the square root of this product will be the area of the triangle.

Bisect any two of the angles, as A and B, with the lines AD, BD, meeting in D; draw the perpendiculars DE, DF, DG.

The triangle AFD is equiangular to AED; for the angle $FAD=EAD$ by construction, and $AFD=AED$, being each a right angle, and of consequence $ADF=ADE$; wherefore $AD : DE :: AD : DF$; and since AD bears the same proportion to DF that it does to DE, $DF=DE$, and the triangle $AFD=AED$. The same way $DE=DG$, and the triangle $DEB=DGB$, and $FD=DE=DG$; therefore D will be the centre of a circle that will pass through E, F, G.

In the same way, if A and C were bisected, the same point D would be had; therefore a line from D to C will bisect C, and thus the triangles DFC, DGC will be also equal.

Produce CA to H, till $AH=EB$ or GB; so will HC be equal to half the sum of the sides, viz. to $\frac{1}{2}AB+\frac{1}{2}AC+\frac{1}{2}BC$; for FC, FA, EB are severally equal to CG, AE, BG; and all these together are equal to the sum of the sides of the triangle; therefore $FC+FA+EB$ or CH are equal to half the sum of the sides.

$FC=CH-AB$, for $AF=AE$, and $HA=EB$; therefore $HF=AB$, and $AF=CH-BC$; for $CF=CG$, and $AH=GB$; therefore $BC=HA+FC$, and $AC=CH-AH$.

Continue DC till it meets a perpendicular drawn upon H in K; and from K draw the perpendicular KI, and join AK.

Because the angles AHK and AIK are two right ones, the angles HAI and K together are equal to two right; since the angles of the two triangles contain four right: in the same way $FDE+FAE=$ (two right angles $=$) $FAE+IAH$; let FAE be taken from both, then $FDE=IAH$, and of course $FAE=K$; the quadrilateral figures $AFDE$ and $KHAI$ are therefore similar, and have the sides about the equal angles proportional;

and it is plain the triangles CFD and CHK are also proportional: hence,

$$FD : HA :: FA : HK$$
$$FD : FC :: HK : HC.$$

Wherefore, by multiplying the extremes and means in both, it will be the square of $FD \times HK \times HC = FC \times FA \times HA \times HK$: let HK be taken from both, and multiply each side by CH; then the square of $CH \times$ by the square of $FD = FC \times FA \times HA \times CH$.

It is plain by the foregoing problem, that $\frac{1}{2}AB \times DE + \frac{1}{2}BC \times DG + \frac{1}{2}AC \times FD =$ the area of the triangle; or that half the sum of the sides, viz. $CH \times FD =$ the triangle; wherefore, the square of $CH \times$ by the square of $FD = FC \times FA \times HA \times CH$, that is, the half-sum multiplied continually into the differences between the half-sum and each side will be the square of the area of the triangle, and its root the area. Q. E. D.

Cor 1. If all the sides be equal, the rule will become $\sqrt{\frac{3}{2}a \times \frac{1}{2}a \times \frac{1}{2}a \times \frac{1}{2}a} = \frac{1}{4}aa\sqrt{3}$, for the equilateral triangle whose side is a.

Hence the following problem will be evident.

PROBLEM VIII.

The three sides of a plane triangle given, to find the area.

RULE.*

From half the sum of the three sides subtract each side severally; take the logarithms of half the sum and three remainders, and half their total will be the logarithm of the area: or, take the square root of the continued product of the half-sum and three remainders for the area.

EXAMPLES.

PL. 8. *fig.* 9.

1. In the triangle ABC are

$$\text{Given}\left\{\begin{array}{l} AB = 10.64 \\ AC = 12.28 \\ CB = \ \ 9.00 \end{array}\right\}\text{four-pole chains; required the area}$$

Sum 31.92

* The demonstration of this is plain from the foregoing lemma, and the nature of logarithms.

Half-sum	15.96	Log.	1.203033
Remainders	5.32	—	0.725912
	3.68	—	0.565848
	6.96	—	0.842609
			2)3.337402
Answer, sqr. ch.	46.63	log.	1.668701
or,	4.663 acres.		

Or, $15.96 \times 5.32 \times 3.68 \times 6.96 = 2174.71113216$; the square root of which is 46.63, for the area, as before.

2. What quantity of land is contained in a triangle, the three sides of which are 80, 120, and 160 perches respectively?

Ans. 29A. 7P.

3. What quantity of land is contained in a triangle, the three sides of which are 20, 30, and 40 four-pole chains?

Ans. 29A. 7.579P.

4. How many acres are in a triangle, whose sides are 49, 50.25, 25.69 four-pole chains? Ans. 61A. 1R. 39.68P.

PROBLEM IX.

Two sides of a plane triangle and their included angle given, to find the area.

RULE.*

To the log. sine of the given angle (or of its supplement to 180° if obtuse) add the logarithms of the containing sides; the sum less radius will be the logarithm of the double area.

Or, As radius

Is to the sine of any angle of a triangle,

So is the product of the sides including the angle:

To double the area of the triangle.

That is, $\frac{AB \times AC \times \text{Nat. S. of } \angle A}{2}$ (Pl. 5, fig. 17) = the area.

* Demonstration. This follows from rule 2, prob. 5, and from the nature of logarithms, because a triangle is half a parallelogram of the same base and height.

Or thus, Pl. 11, *fig.* 3.

Let AH be perpendicular to AB and equal to AC, and HE, FCG parallel to AB; then making AH ($=AC$) radius, AF ($=CD$) will be the sine of CAD, and the parallelograms $ABEH$ (the product of the given sides) and $ABGF$ (the double area of the triangle), having the same base AB, are in proportion as their heights AH, AF; that is, as radius to the sine of the given angle; which proportion gives the operation as in the rule above.

EXAMPLES.

PL. 5. *fig.* 16.

Suppose two sides *AB*, *AC* of a triangular lot *ABC* form an angle of 30 degrees, and measure one 64 perches, and the other 40.5, what must the contents be?

Given angle	30°	sine	9.698970
Containing sides	64	log.	1.806180
	40.5	log.	1.607455
	2)1296	log.	3.112605

160)648(4A. 8P., Answer.

8

Or thus :

.500000 sine ∠*A*
64 *AB*

32.000000
40.5 *AC*

2)1296.0000000

160)648

4A. 8P.

2. Required the area of a triangle, two sides of which are 49.2 and 40.8 perches, and their contained angle $144\frac{1}{4}$ degrees.
Ans. 3A. 2R. 22P.

3. What quantity of ground is enclosed in an equilateral triangle, each side of which is 100 perches, either angle being 60 degrees? Ans. 27A. 10P.

PROBLEM X.

To find the area of a trapezoid, viz. a figure bounded by four right lines, two of which are parallel, but unequal.

RULE.*

Multiply the sum of the parallel sides by their perpendicular distance, and take half the product for the area.

* Demonstration. The trapezoid *ABCD* (pl. 14, fig. 8) is equivalent to the rectangle contained by its altitude and half the sum of the parallel

EXAMPLES.

1. Required the area of a trapezoid, of which the parallel sides are, respectively, 30 and 49 perches, and their perpendicular distance 61.6.

$$\left.\begin{array}{r}61.6\\ 0+49=79\end{array}\right\}\text{Multiply.}$$

$$\underline{}$$

$$2)4866.4$$

Answer, 2433.2=15A. 33.2P.

Pl. 9. *fig.* 10.

2. In the trapezoid $ABCD$ the parallel sides are, AD 20 perches, BC 32, and their perpendicular distance AB 26; required the contents. Ans. 4A. 36P

PROBLEM XI.

To find the contents of a trapezium.

RULE I.*

Multiply the diagonal, or line joining the remotest opposite angles, by the sum of the two perpendiculars falling from the other angles to that diagonal, and half the product will be the area.

sides BC and AD. For draw CE parallel to AB (prob. 6), bisect ED in F, and draw FG parallel to AB, meeting the production of BC in G. Because BC is equal to AE, BC and AD are together equal to AE and AD, or to twice AE with ED, or to twice AE and twice EF, that is, to twice AF; consequently, $AF=\frac{1}{2}(BC+AD)$. Wherefore, the rectangle contained by the altitude of the trapezoid and half the sum of its parallel sides is equivalent to the rhomboid BF: but the rhomboid EG is equivalent to the triangle ECD (theo. 12, cor. 2); add to each the rhomboid BE, and the rhomboid BF is equivalent to the trapezoid $ABCD$.

Note.—On this proposition is founded the method of offsets, which enters so largely into the practice of land surveying. In measuring a field of a very irregular shape, the principal points only are connected by straight lines, forming sides of the component triangles, and the distance of each remarkable flexure of the extreme boundary is taken from these rectilineal traces. The exterior border of the polygon is therefore considered as a collection of trapezoids, which are measured by multiplying the mean of each pair of offsets or perpendiculars into their base or intermediate distance, which is one of the other sides, because the parallel sides are perpendicular to it.

* Demonstration. For the trapezium $ABDC$ = the triangles $ABC+ADC=\frac{AC\times Bb}{2}+\frac{AC\times Dd}{2}=\frac{Bb+Dd}{2}\times AC$. Q. E. D.

EXAMPLE.

Pl. 7. *fig.* 3.

Let *ABCD* be a field in form of a trapezium, the diagonal *AC* 64.4 perches, the perpendicular *Bb* 13.6, and *Dd* 27.2; required the contents.

$$\left.\begin{array}{r}\text{Diagonal}=64.4\\ 13.64+27.2=40.8\end{array}\right\}\text{Multiply.}$$

2)2627.52

160)131376(8A. $33\frac{3}{4}$P., Answer.
1280

$33\frac{3}{4}$ perches.

Note.—The method of multiplying together the half-sums of the opposite sides of a trapezium for the contents is erroneous, and the more so the more oblique its angles are.

To draw the map, set off *Ab* 28 perches, and *Ad* 34.4, and there make the perpendiculars to their proper lengths, and join their extremities to those of the diagonal.

Note.—When one of the diagonals and the four sides of a trapezium are given, it is divided into two triangles whose sides are given; the area of each triangle may be found (by prob 8), and their sum will give the area of the trapezium.

RULE II.*

If there be drawn two diagonals cutting each other, the product of the diagonals multiplied by the natural sine of the angle of intersection of the diagonals will be double the area. And this rule is common to a square, rhombus, rhomboides, &c., as well as to all other quadrilateral figures; that is, $\frac{AC\times BD\times \text{Nat. S.}\angle R}{2}$ = the area. Pl. 14, fig. 9. Or, as radius : $S.\angle R$: : $\frac{1}{2}AC\times BD$: the area.

Note.—Because the diagonals of a square and rhombus intersect at a right angle, whose sine is 1, therefore half the product of their diagonals is the area.

* Demonstration. Pl. 14, fig. 9. For the trapez. = the four $\triangle$s *ARB*, *BRC*, *CRD*, *DRA* $=(AR\times RB+BR\times RC+CR\times RD+DR\times RA)\times\frac{1}{2}S.\angle R$ $=(\overline{AR+RC}\times BR+\overline{CR+RA}\times DR)\times\frac{1}{2}S.\angle R=\overline{AR+RC}\times\overline{BR+RD}\times\frac{1}{2}S.\angle R=AC\times BD\times\frac{1}{2}S.\angle R$. Q. E. D

EXAMPLE.

Let the two diagonals be 40 and 30 chains, and at their intersection one of the less angles is 48°; the area is required.

Then, since the natural sine of 48° is .7431448, the area $= \frac{40 \times 30 \times .7431448}{2} = 600 \times .7431448 = 445.88688$ sq. chains = 44A. 2R. 14.19P.

By Logarithms.

Radius	10.000000
Sine of 48°	9.871073
$\frac{40 \times 30}{2} = 600$	2.778151
Area 445.8869	2.649224

To find the area of a trapezium when three side sand the two included angles are given.

EXAMPLE.

In a quadrangular field the south side is 23.4, the east side 19.75, and the north side 20.5 chains; also the south-east and north-east angles are 73° and 87° 30′. What is the area?

First (by rule 2, prob. 6), $\frac{.9990482 \times 19.75 \times 20.5}{2} = .4995241 \times 19.75 \times 20.5 = 202.24482$, the area of the north-east triangle *BDC*. Pl. 14, fig. 10.

Again, 40.25 $(=BC+CD)$: .75 $(=BC-CD)$: : 1.0446136 (tang. of $\frac{BDC+CBD}{2} = 46° \ 15'$) : $\frac{1.0446136 \times 3}{161} = .01946485$ = the tang. of $\frac{BDC-CBD}{2} = 1° \ 07'$.

Wherefore, $\angle BDC = 46° \ 15' + 1° \ 07' = 47° \ 22'$; and $\angle ADB = (ADC - CDB = 73° - 47° \ 22' =) \ 25° \ 38'$.

But $\angle BDC$	47° 22′	9.8667026
$\angle C$	87° 30′	9.9995865
CB	20.5	1.3117539
BD		1.4446378

Whence (by rule 2, prob. 6),

$\frac{1}{2}AD$	11.7	1.0681859
BD		1.4446378
S. $\angle ADB$	25° 38′	9.6360969
140.9031 the area of the $\triangle ABD$		2.1489206

Their sum is 343.1479 sq. chains = 34A. 1R. and 10.3664P., the area required.

EXAMPLES FOR PRACTICE.

1. Required the area of a trapezium whose diagonal measures 120 perches, and the perpendiculars 24 perches and 40 perches. Ans. 24 acres.

2. Required the area of a trapezium whose diagonals are 85 and 24 four-pole chains, and at their intersection one of the less angles is 30°. Ans. 105A.

3. What is the area of a trapezium whose south side is 27.4 chains, east side 35.75 chains, north side 37.55 chains, and west side 41.05 chains; also the diagonal from south-west to north-east 48.35 chains? Ans. 123A. 11.867P.

PROBLEM XII.

To find the area of a circle or an ellipsis.

RULE.

Multiply the square of the circle's diameter, or the product of the longest and shortest diameters of the ellipsis, by .7854 for the area. Or, subtract 0.104909 from the double logarithm of the circle's diameter, or from the sum of the logarithms of those elliptic diameters, and the remainder will be the logarithm of the area.

Note.—In any circle the

$$\left.\begin{array}{l}\text{Diam. multiplied}\\ \text{Circum. divided}\end{array}\right\}\text{ by } 3.14159 \left\{\begin{array}{l}\text{produces the circum.}\\ \text{quotes the diam.}\end{array}\right.$$

EXAMPLES.

1. How many acres are in a circle of a mile diameter?

1 mile = 320 perches, log. 2.505150
2.505150

5.010300
0.104909

4|0)8042|5 log. 4.905391

4)2010.25

Answer, 502A. 2R. 25P.

2. A gentleman, knowing that the area of a circle is greater than that of any other figure of equal perimeter, walls in a circular deer-park of 100 perches diameter, in which he makes an elliptical fish-pond 10 perches long by 5 wide. Required the length of his wall, contents of his park, and area of his pond.

Answer. The wall 314.16 perches, enclosing 49A. 14P., of which 39¼ perches, or ¼ of an acre nearly, is appropriated to the pond.

PROBLEM XIII.

The area of a circle given, to find its diameter.

RULE.

To the logarithm of the area add 0.104909, and half the sum will be the logarithm of the diameter. Or, divide the area by .7854, and the square root of the quotient will be the diameter.

EXAMPLE.

A horse in the midst of a meadow suppose
Made fast to a stake by a line from his nose:
How long must this line be that, feeding all round,
Permits him to graze just an acre of ground?

Area in perches 160, log.		2.204120
		0.104909
		2)2.309029
Diameter 2)14.2733	log.	1.154514

Answer, 7.13665 per. = 117*ft.* 9*in.*

PROBLEM XIV.

Allowance for roads.

It is customary to deduct 6 acres out of 106 for roads; the land before the deduction is made may be termed the *gross*, and that remaining after such deduction the *neat*.

RULE.

The gross divided by 1.06 quotes the neat.
The neat multiplied by 1.06 produces the gross.

EXAMPLES.

1. How much land must I enclose to have 850A. 2R. 20P. neat?

40|20
4| 2.5

———— Acres. A. R. P.

850.625 × 1.06 = 901.6625 = 901 2 26, the answer.

2. How much neat land is there in a tract of 901A. 2R. 26P gross?

40|26
4| 2.65

———— Acres. A. R. P.

1.06)901.6625(850.625 = 850 2 20, the answer.
848

————

&c.

Note.—These two operations prove each other.

PROBLEM XV.

To find the area of a piece of ground, be it ever so irregular, by dividing it into triangles and trapezia.

PL. 7. *fig.* 4.

We here admit the survey to be taken and protracted; by having, therefore, the map, and knowing the scale by which it was laid down, the contents may be thus obtained.

Dispose the given map into triangles by fine pencilled lines, such as are here represented in the scheme, and number the triangles with 1, 2, 3, 4, &c. Your map being thus prepared, rule a table with four columns, the first of which is for the number of the triangle, the second for the base of it, the third for the perpendicular, and the fourth for the contents in perches.

Then proceed to measure the base of number 1, from the scale of perches the map was laid down by, and place that in the second column of the table, under the word base; and from the angle opposite to the base open your compasses so as when one foot is in the angular point, the other, being moved backward and forward, may just touch the base line, and neither go the least above nor beneath it; that distance in the compasses, measured from the same scale, is the length of that perpendicular, which place in the third column under the word perpendicular.

If the perpendiculars of two triangles fall on one and the same base, it is unnecessary to put down the base twice, but insert the second perpendicular opposite to the number of the triangle in the table, and join it with the other perpendicular by a brace, as Nos. 1 and 2, 4 and 5, 6 and 7, 9 and 10, &c.

Proceed after this manner till you have measured all the triangles, and then, by prob. 6, find the contents in perches of each respective triangle, which severally place in the table opposite to the number of the triangle, in the fourth column, under the word contents.

But where two perpendiculars are joined together in the table by a brace, having both one and the same base, find the contents of each (being a trapezium) in perches, by prob. 11, which place opposite the middle of those perpendiculars, in the fourth column, under the word contents.

Having thus obtained the contents of each respective triangle and trapezium which the map contains, add them all together, and their sum will be the contents of the map in perches, which being divided by 160 gives the contents in acres. Thus, for

EXAMPLE.

No.	Base.	Perpend.	Contents.
1	24.8	17.0	412.92
2		16.3	
3	28.2	16.0	225.6
4	39.8	19.6	712.42
5		16.2	
6	49.4	29.0	1086.8
7		15.0	
8	38.7	6.7	129.64
9	40.0	17.0	600
10		13.0	
11	42.8	10.2	481.5
12		12.3	
13	26.2	17.9	234.49
14	24.0	11.6	259.2
15		10.0	
Contents in perches - - -			4142.57

This being divided by 160 will give 25A. 3R. 22P., the contents of the map.

Let your map be laid down by the largest scale your paper will admit, for then the bases and perpendiculars can be measured with greater accuracy than when laid down by a smaller scale, and if possible measure from scales divided diagonally.

If the bases and perpendiculars were measured by four-pole chains, the contents of every triangle and trapezium may be had as before in problems 6 and 11, and consequently the whole contents of the map.

If any part of your map has short or crooked bounds, as those represented in plate 7, fig. 5, then by the straight edge of a transparent horn draw a fine pencilled line, as *AB*, to balance the parts taken and left out, as also another *BC*: these parts, when small, may be balanced very nearly by the eye, or they may be more accurately balanced by method the third. Join the points *A* and *C* by a line, so will the contents of the triangle *ABC* be equal to that contained between the line *AC* and the crooked boundary from *A* to *B*, and to *C*: by this method the number of triangles will be greatly lessened, and the contents become more certain; for the fewer operations you have the less subject will you be to err, and if an error be committed the sooner it may be discovered.

The lines of the map should be drawn small and neat, as well as the bases, the compasses neatly pointed, and the scale accurately divided; without all which you may err greatly. The multiplications should be run over twice at least, as also the addition of the column of contents.

From what has been said it will be easy to survey a field by reducing it into triangles and measuring the bases and perpendiculars by the chain. To ascertain the contents only it is not material to know at what part of the base the perpendicular was taken; since it has been shown (in cor. to theo. 13 geom.) that triangles on the same base and between the same parallels are equal: but if you would draw a map from the bases and perpendiculars, it is evident that you must know at what part of the base the perpendicular was taken, in order to set it off in its due position; and hence the map is easily constructed.

PROBLEM XVI.

PL. 8. *fig.* 5.

To determine the area of a piece of ground, having the map given, by reducing it to one triangle equal thereto, and thence finding its contents.

Let *ABCDEFGH* be a map of ground which you would reduce to one triangle equal thereto.

Produce any line of the map, as *AH*, both ways; lay the edge of a parallel ruler from *A* to *C*, having *B* above it; hold the other side of the ruler, or that next you, fast; open till the same edge touches *B*, and by it, with a protracting pin, mark the point *b* on the produced line; lay the edge of the ruler from *b* to *D*, having *C* above it, hold the other side fast, open till the same edge touches *C*, and by it mark the point *c* on the produced line. A line drawn from *c* to *D* will take in as much as it leaves out of the map.

Again, lay the edge of the ruler from *H* to *F*, having *G* above it; keep the other side fast, open till the same edge touches *G*, and by it mark the point *g* on the produced line; lay the edge of the ruler from *g* to *E*, having *F* above it, keep the other side fast, open till the same edge touches *F*, and by it mark the point *f* on the produced line. Lay the edge of the ruler from *f* to *D*, having *E* above it, keep the other side fast, open till the same edge touches *E*, and by it mark the point *e* on the produced line. A line drawn from *D* to *e* will take in as much as it leaves out. Thus have you the triangle *cDe*, equal to the irregular polygon *ABCDEFGH.**

If, when the ruler's edge is applied to the points *A* and *C*, the point *B* falls under the ruler, hold that side next the said points fast, and draw back the other to any convenient distance; then hold this last side fast, and draw back the former edge to *B*, and by it mark *b* on the produced line; and thus a parallel may be drawn to any point under the ruler as well as if it were above it. It is best to keep the point of your protracting pin in the last point in the extended line till you lay the edge of the ruler from it to the next station, or you may mistake one point for another.

This may also be performed with a scale or ruler which has a thin-sloped edge, called a fiducial edge, and a fine-pointed pair of compasses. Thus,

Lay that edge on the points *A* and *C*; take the distance from the point *B* to the edge of the scale, so that it may only touch it, in the same manner as you take the perpendicular of a tri-

* The demonstration of this is evident from prob. 19, Geom., page 63 of this book.

angle; carry that distance down by the edge of the scale parallel to it to b, and there describe an arc on the point b, and if it just touches the ruler's edge the point b is in the true place of the extended line. Lay then the fiducial edge of the scale from b to D, and take a distance from C that will just touch the edge of the scale; carry that distance along the edge till the point which was in C cuts the produced line in c; keep that foot in c and describe an arc, and if it just touches the ruler's edge the point c is in the true place of the extended line. Draw a line from c to D and it will take in and leave out equally: in like manner the other side of the figure may be balanced by the line eD.

Let the point of your compasses be kept to the last point of the extended line till you lay your scale from it to the next station, to prevent mistakes from the number of points.

That the triangle cDe is equal to the right-lined figure $ABCDEFGH$ will be evident from problems 18, 19, geom.; for thereby, if a line were drawn from b to C, it will give and take equally, and then the figure $bCDEFGH$ will be equal to the map. Thus the figure is lessened by one side, and the next balance line will lessen it by two, and so on, and will give and take equally. In the same manner an equality will arise on the other side.

The area of the triangle is easily obtained, as before, and thus you have the area of the map.

It is best to extend one of the shortest lines of the polygon; because if a very long line be produced, the triangle will have one angle very obtuse, and consequently the other two very acute; in which case it will not be easy to determine exactly the length of the longest side, or the points where the balancing lines cut the extended one.

This method will be found very useful and ready in small enclosures, as well as very exact; it may be also used in large ones, but great care must be taken of the points on the extended line, which will be crowded, as well as of not missing a station.

PROBLEM XVII.

A map with its area being given, and its scale omitted to be either drawn or mentioned, to find the scale.

Cast up the map by any scale whatsoever, and it will be
As the area found
Is to the square of the scale by which you cast up,
So is the given area of the map
To the square of the scale by which it was laid down.
The square root of which will give the scale.

EXAMPLE.

A map whose area is 126A. 3R. 16P. being given, and the scale omitted to be either drawn or mentioned, to find the scale.

Suppose this map was cast up by a scale of 20 perches to an inch, and the contents thereby produced be 31A. 2R. 34P.

As the area found, 31A. 2R. 34P.=5074P.
Is to the square of the scale by which it was cast up, that is, to 20×20=400,
So is the given area of the map 126A. 3R. 16P.=20296P.
To the square of the scale by which it was laid down.

5074 : 400 :: 20296 : 1600, the square of the required scale.

```
     Root.
    1600(40
    16
    ----
 8)   00
    ----
```

Answer. The map was laid down by a scale of 40 perches to an inch.

PROBLEM XVIII.

How to find the true contents of a survey, though it be taken by a chain that is too long or too short.

Let the map be constructed, and its area found, as if the chain were of the true length. And it will be,

As the square of the true chain
Is to the contents of the map,
So is the square of the chain you surveyed by
To the true contents of the map.

EXAMPLE.

If a survey be taken with a chain which is 3 inches too long, or with one whose length is 42 feet 3 inches, and the map thereof be found to contain 920A. 2R. 20P.; required the true contents.

As the square of 42*ft.* 0*in.* = the square of 504 inches = 254016
Is to the contents of the map, 920A. 1R. 20P.=147260P.,
So is the square of 42*ft.* 3*in.* = the square of 507 inches = 257049
To the true contents.

P. P.
250416 : 147260 : : 257049 : 149019
A. R. P.
160)149019(931 1 19, Answer.

501

219

40)59(1R.

19P.

METHOD OF DETERMINING THE AREAS OF RIGHT-LINED FIGURES UNIVERSALLY, OR BY CALCULATION.

Definitions.

Pl. 8. *fig.* 7.

1. Meridians are north and south lines, which are supposed to pass through every station of the survey.

2. The difference of latitude, or the northing or southing of any stationary line, is the distance that one end of the line is north or south from the other end; or, it is the distance which is intercepted on the meridian, between the beginning of the stationary line and a perpendicular drawn from the other end to that meridian. Thus, if *NS* be a meridian line passing through the point *A* of the line *AB*, then is *Ab* the difference of latitude or southing of that line.

3. The departure of any stationary line is the nearest distance from one end of the line to a meridian passing through the other end. Thus *Bb* is the departure or easting of the line *AB*: but if *CB* be a meridian, and the measure of the stationary distance be taken from *B* to *A*, then is *BC* the difference of latitude, or northing, and *AC* the departure or westing of the line *BA*.

4. That meridian which passes through the first station is sometimes called the first meridian; and sometimes it is a meridian passing on the east or west side of the map, at the distance of the breadth thereof, from east to west, set off from the first station.

5. The meridian distance of any station is the distance

thereof from the first meridian, whether it be supposed to pass through the first station or on the east or west side of the map.

THEOREM I.

In every survey which is truly taken, the sum of the northings will be equal to that of the southings; and the sum of the eastings equal to that of the westings.

PL. 9. *fig.* 1.

Let *abcefgh* represent a plot or parcel of land. Let *a* be the first station, *b* the second, *c* the third, &c. Let *NS* be a meridian line; then will all lines parallel thereto, which pass through the several stations, be meridians also; as *ao*, *bs*, *cd*, &c., and the lines *bo*, *cs*, *dc*, &c., perpendicular to those, will be the east or west lines or departures.

The northings, $ei+go+hq=ao+bs+cd+fr$, the southings: for let the figure be completed; then it is plain that $go+hq+rk=ao+bs+cd$, and $ei—rk=fr$. If to the former part of this first equation $ei—rk$ be added, and fr to the latter, then $go+hq+ei=ao+bs+cd+fr$, that is, the sum of the northings is equal to that of the southings.

The eastings, $cs+qa=ob+de+if+rg+oh$, the westings. For $aq+yo$ (az) $=de+if+rg+oh$, and $bo=cs—yo$. If to the former part of this first equation $cs—yo$ be added, and bo to the latter, then $cs+aq=ob+de+if+rg+oh$; that is, the sum of the eastings is equal to that of the westings. Q. E. D.

SCHOLIUM.

This theorem is of use to prove whether the field-work be truly taken or not; for if the sum of the northings be equal to that of the southings, and the sum of the eastings to that of the westings, the field-work is right, otherwise not.

Since the proof and certainty of a survey depend on this truth, it will be necessary to show how the difference of latitude and departure for any stationary line, whose course and distance are given, may be obtained by the table usually called the Traverse Table.*

* This table is calculated by the first case of right-angled plane trigonometry, taught in the fifth section of the first part of this book, where the hypothenuse and an acute angle are given, to find the legs.

In the right-angled triangle *ABC* (Pl. 8, fig. 7), given the distance or hypothenuse *AB* 91 chains, links, or perches, the course or one of the acute angles *ABC* 41°; it is required to find the legs, or the difference of latitude and departure.

To find the difference of latitude and departure by the Traverse Table.

This table is so contrived, that by finding therein the given course, and a distance not exceeding 120 miles, chains, perches, or feet, the difference of latitude and departure is had by inspection: the course is to be found at the top of the table when under 45 degrees, but at the bottom of the table when above 45 degrees. Each column signed with a course consists of two parts, one for the difference of latitude, marked Lat., the other for the departure, marked Dep., which names are both at the top and bottom of these columns. The distance is to be found in the column marked Dist., next the left-hand margin of the page.

EXAMPLE.

In the use of this table, a few observations only are necessary.

1. If a station consist of any number of even chains or perches (which are almost the only measures used in surveying), the latitude and departure are found at sight under the bearing or course, if less than 45 degrees, or over it if more, and in a line with the distance.

2. If a station consist of any number of chains and perches, and decimals of a chain or perch, under the distance 10, the lat. and dep. will be found as above, either over or under the bearing; the decimal point or separatrix being removed one figure to the left, which leaves a figure to the right to spare.

If the distance be any number of chains or perches, and the decimals of a chain or perch, the lat. and dep. must be taken

---

As radius	90°	10.000000
is to *AB*,	91	1.959041
So is the sine of *B* 41°		9.816943
to *AC*	59.70	1.775984
As radius	90°	10.000000
is to *AB*,	91	1.959041
So is the sine of *A* 49°		9.877780
to *BC*	68.68	1.836821

Hence *AC* is the departure and *BC* the difference of latitude which correspond to those in the table. In the same manner the difference of latitude and departure to every degree in the table is calculated, by which the practitioner can at any time prove the exactness of those in the table.

out at two or more operations, by taking out the lat. and dep for the chains or perches in the first place; and then for the decimal parts.

To save the repeated trouble of additions, a judicious surveyor will always limit his stations to whole chains or perches and lengths, which can commonly be done at every station save the last.

1. In order to illustrate the foregoing observations, let us suppose a course or bearing to be *S.* 35° 15′ *E.*, and the distance 79 four-pole chains. Under 35° 15′, or 35¼ degrees, and opposite 79, we find 64.51 for the latitude, and 45.59 the departure, which signify that the end of that station differ in latitude from the beginning 64.51 chains, and in departure 45.59 chains.

Note.—We are to understand the same things if the distance is given in perches or any other measures, the method of proceeding being exactly the same in every case.

Again, let the bearing be 54¾ degrees, and distance as before; then over said degrees we find the same numbers, only with this difference, that the lat. before found will now be the dep., and the dep. the lat., because 54¾ is the complement of 35¼ degrees to 90, viz. lat. 45.59, dep. 64.51.

2. Suppose the same course, but the distance 7 chains 90 links, or as many perches. Here we find the same numbers, but the decimal point must be removed one figure to the left.

Thus, under 35¼, and in a line with 79 or 7.9, are

Lat. 6.45
Dep. 4.56

the 5 in the dep. being increased by 1, because the 9 is rejected; but over 54¾ we get

Lat. 4.56
Dep. 6.45

3. Let the course be as before, but the distance 7.79, then opposite

7.70	Lat. 6.29	Dep. 4.43
9	7	6
7.79	6.36	4.49

Or opposite

7.00	Lat. 5.72	Dep. 4.03
.79	.64	.46
7.79	6.36	4.49

THEOREM II.

When the first meridian passes through the map.

If the east meridian distances in the middle of each line be multiplied into the particular southing, and the west meridian distances into the particular northing, the sum of these products will be the area of the map.

PL. 10. *fig.* 1.

Let the figure *abkm* be a map, the lines *ab*, *bk* to the southward, and *km*, *ma* to the northward, NS the first meridian line passing through the first station *a*.

$$\text{The meridian distances east} \left\{ \begin{array}{l} zd \times ao \\ tu \times ox\ (bq) \end{array} \right\} = \text{Area} \left\{ \begin{array}{l} am \\ ow \end{array} \right.$$

$$\text{The meridian distances west} \left\{ \begin{array}{l} ef \times gx \\ hh \times ga\ (my) \end{array} \right\} = \text{Area} \left\{ \begin{array}{l} xp \\ gl \end{array} \right.$$

These four areas $am+ow+xp+gl$ will be the area of the whole figure *cmswiprlc*, which is equal to the area of the map *abkm*. Complete the figure.

The parallelograms *am* and *ow* are made of the east meridian distances *dz* and *tu* multiplied into the southings *ao* and *ox*; the parallelograms *xp* and *gl* are composed of the west meridian distances *ef* and *hh* multiplied into the northings *xg* and *ga* (*my*): but these four parallelograms are equal to the area of the map; for if from them be taken the four triangles marked *Z*, and in the place of those be substituted the four triangles marked *O*, which are equal to the former, then it is plain the area of the map will be equal to the four parallelograms. Q. E. D.

THEOREM III.

If the meridian distance when east be multiplied into the southings, and the meridian distance when west be multiplied into the northings, the sum of these less by the meridian distance when west multiplied into the southings is the area of the survey.

PL. 10. *fig.* 2.

Let *abc* be the map.

The figure being completed, the rectangle *af* is made of the meridian distance *eq* when east multiplied into the southing *an*; the rectangle *yk* is made of the meridian distance *xw*, multiplied into the northings *cz* or *ya*. These two rectangles, or parallelograms, $af+yk$, make the area of the figure *dfnyikd*; from which taking the rectangle *oy*, made of the meridian distance *tu* when west into the southings *oh* or *bm*, the remainder

is the area of the figure *dfohikd*, which is equal to the area of the map.

Let $bou=Y$, $urih=L$, $ric=O$, $wrc=Z$, $akw=K$, $cfb=B$, and $ade=A$. I say that $Y+Z+B=K+L+A$.

$Y=L+O$; add Z to both, then $Y+Z=L+O+Z$: but $Z+O=K$, put K instead of $Z+O$, then $Y+Z=L+K$; add to both sides the equal triangles B and A, then $Y+Z+B=L+K+A$. If therefore $B+Y+Z$ be taken from *abc*, and in lieu thereof we put $L+K+A$, we shall have the figure *dfohikd* $=abc$; but that figure is made up of the meridian distance when east multiplied into the southing, and the meridian distance when west multiplied into the northing less by the meridian distance when west multiplied into the southing. Q. E. D.

COROLLARY.

Since the meridian distance when west multiplied into the southing is to be subtracted, by the same reasoning the meridian distance when east multiplied into the northing must be also subtracted.

SCHOLIUM.

From the two preceding theorems we learn how to find the area of the map when the first meridian passes through it; that is, when one part of the map lies on the east and the other on the west side of that meridian. Thus,

RULE.

The merid. dist. when $\left\{\begin{matrix}\text{east}\\ \text{west}\end{matrix}\right\}$ multiplied into the $\left\{\begin{matrix}\text{southings,}\\ \text{northings,}\end{matrix}\right\}$ their sum is the area of the map.

But,

The merid. dist. when $\left\{\begin{matrix}\text{east}\\ \text{west}\end{matrix}\right\}$ multiplied into the $\left\{\begin{matrix}\text{northings,}\\ \text{southings,}\end{matrix}\right\}$ the sum of these products taken from the former gives the area of the map.

These theorems are true when the surveyor keeps the land he surveys on his right-hand, which we suppose through the whole to be done; but if he goes the contrary way, call the southings northings and the northings southings, and the same rule will hold good.

General Rule for finding the Meridian Distances.

1. The meridian distance and departure both east or both west, their sum is the meridian distance of the same name.

2. The meridian distance and departure of different names, that is, one east and the other west, their difference is the meridian distance of the same name with the greater.

Thus, in the first method of finding the area, as in the following field-book,

The first departure is put opposite the northing or southing of the first station, and is the first meridian distance of the same name. Thus, if the first departure be east, the first meridian distance will be the same as the departure, and east also, and if west it will be the same way.

The first meridian distance	6.61 E.
The next departure	6.61 E.
The second meridian distance	13.22 E.
The next departure	1.80 E.
The third meridian distance	15.02 E.
At station 5, the meridian distance	5.78 E.
The next departure	7.76 W
The next meridian distance	1.98 W.
At station 11, the meridian distance	0.12 W.
The next departure	5.84 E.
The next meridian distance	5.72 E.

PL. 10. *fig.* 3.

In the 5th and 11th stations, the meridian distance being less than the departures and of a contrary name, the map will cross the first meridian, and will pass, as in the 5th line, from the east to the west line of the meridian; and in the 11th line it will again cross from the west to the east side, which will evidently appear if the field-work be protracted, and the meridian line passing through the first station be drawn through the map.

The field-book cast up by the first method will be evident

from the two foregoing theorems, and therefore requires no further explanation; but *to find the area by the second method* take this

RULE.

When the meridian distances are east, put the products of north and south areas in their proper columns, but when west in their contrary columns; that is, in the column of south area when the difference of latitude is north, and in north when south: the reason of which is plain from the last two theorems. The difference of these two columns will be the area of the map.

Construction of the Map from either the first or the second Table.

Pl. 10. *fig*. 3.

Draw the line NS for a north and south line, which call the first meridian; in this line assume any point, as 1, for the first station. Set the northing of that stationary line, which is 3.54, from 1 to 2, on the said meridian line. Upon the point 2 raise a perpendicular to the eastward, the meridian distance being easterly, and upon it set 13.22, the second number in the column of meridian distances from 2 to 2, and draw the line 1, 2 for the first distance line: from 2 upon the first meridian set the northing of the second stationary line, that is, 9.65, to 3, and on the point 3 erect a perpendicular eastward, upon which set the meridian distance of the second station 16.82, from 3 to 3, and draw the line 2, 3, for the distance line of the second station. And since the third station has neither northing nor southing, set the meridian distance of it 33.02, from 3 to 4, for the distance line of the third station. To the fourth station there is 29.44 southing, which set from 3 to 5; upon the point 5 erect the perpendicular 5, 5; on which lay 13.54, and draw the line 4 to 5.

In the like manner proceed to set the northings and southings on the first meridian, and the meridian distances upon the perpendiculars raised to the east or west; the extremities of which connected by right lines will complete the map.

Field-book, Method I.

No. St.	Bearings.	C. L.	Lat. and half Dep.	Merid. Dist.	Area.	Deduct.
1	NE 75°	13.70	N 3.54 E 6.61	6.61 E 13.22 E		23.3994
2	NE 20½	10.30	N 9.67 E 1.80	15.02 E 16.82 E		144.9430
3	East.	16.20	0.00 E 8.10	24.92 E 33.02 E		
4	SW 33½	35.30	S 29.44 W 9.74	23.28 E 13.54 E	685.3632	
5	SW 76	16.00	S 3.87 W 7.76	5.78 E 1.98 W	22.3686	
6	North.	9.00	N 9.00 0.00	1.98 W 1.98 W	17.8200	
7	SW 84	11.60	S 1.21 W 5.77	7.75 W 13.52 W		9.3775
8	NW 53¼	11.60	N 6.94 W 4.64	18.16 W 22.80 W	126.0304	
9	NE 36¾	19.20	N 15.38 E 5.74	17.06 W 11.32 W	262.3828	
10	NE 22½	14.00	N 12.93 E 2.68	8.64 W 5.96 W	111.7152	
11	SE 76¾	12.00	S 2.75 E 5.84	0.12 W 5.72 E		0.3300
12	SW 15	10.85	S 10.48 W 1.40	4.32 E 2.92 E	45.2736	
13	SW 16¾	10.12	S 9.69 W 1.46	1.46 E 0.00	14.1474	
					1285.1012 178.0499	178.0499
	Contents in chains - - -				1107.0513	

The foregoing Field-book, Method II.

It is needless here to insert the columns of bearing or distances in chains, they being the same as before.

No. St.	Lat. and half Dep.	Merid. Dist.	N. Area.	S. Area.
1	N 3.54 E 6.61	6.61 E 13.22 E	23.3994	
2	N 9.65 E 1.80	15.02 E 16.82 E	144.9430	
3	0.00 E 8.10	24.92 E 33.02 E		
4	S 29.44 W 9.74	23.28 E 13.54 E		685.3632
5	S 3.87 W 7.76	5.78 E 1.98 W		22.3686
6	N 9.00 0.00	1.98 W 1.98 W		17.8200
7	S 1.21 W 5.77	7.75 W 13.52 W	9.3775	
8	N 6.94 W 4.64	18.16 W 22.80 W		126.0303
9	N 15.38 E 5.74	17.06 W 11.32 W		262.3828
10	N 12.93 E 2.68	8.64 W 5.96 W		111.7152
11	S 2.75 E 5.84	0.12 W 5.72 E	0.3300	
12	S 10.48 W 1.40	4.32 E 2.92 E		45.2736
13	S 9.69 W 1.46	1.46 E 0.00		14.1474
			178.0499	1284.1012 178.0499
		Area in chains, as before,		1107.0513

A Specimen of the Pennsylvania Method of CALCULATION; *which for its simplicity and ease in finding the Meridian Distances is supposed to be preferable in practice to any thing heretofore published on the subject.*

Find, in the first place, by the Traverse Table, the lat. and dep. for the several courses and distances, as already taught; and if the survey be truly taken, the sums of the northings and southings will be equal, and also those of the eastings and westings. Then, in the next place, find the meridian distances, by choosing such a place in the column of eastings or westings as will admit of a continual addition of one, and subtraction of the other; by which means we avoid the inconvenience of changing the denomination of either of the departures.

The learner must not expect that in real practice the columns of lat. and those of dep. will exactly balance when they are at first added up, for little inaccuracies will arise, both from the observations taken in the field and in chaining; which to adjust, previous to finding the meridian distances, we may observe, that if in small surveys the difference amount to two-tenths of a perch for every station, there must have been some error committed in the field; and the best way in this case will be, to rectify it on the ground by a resurvey, or at least as much as will discover the error. But when the differences are not within those limits, the columns of northing, southing, easting, and westing may be corrected as follows:

Add all the distances into one sum, and say, as that sum is to each particular distance, so is the differenee between the sums of the columns of northing and southing to the correction of northing or southing belonging to that distance: the corrections thus found are respectively additive when they belong to the column of northing or southing which is the less of the two, and subtractive when they belong to the greater; if the course be due east or west, the correction is always additive to the less of the two columns of northing or southing. The corrections of easting and westing are found exactly in the same manner.

The following example will sufficiently illustrate the manner of applying the rule.

EXAMPLE OF CORRECTING A SURVEY.

Field-Notes.			From the Tables.				Corrected.			
No.	Courses.	Dist. Per.	N.	S.	E.	W.	N.	S.	E.	W.
1	S 40° W	70		53.6		45.0		53.6		45.0
2	N 45° W	89	62.9			62.9	62.9			62.9
3	N 36 E	125	101.1		73.5		101.2		73.5	
4	North.	54	54.0				54.0			
5	S 81 E	186		29.1	183.7			29.0	183.6	
6	S 8 W	137		135.7		19.1		135.6		19.2
7	West.	130				130.0	00.1			130.0
			218.0	218.4	257.2	257.0	218.2	218.2	257.1	257.1
				218.0	257.0					
			Diff.	=.4	.2 = Diff.					

In this example, the sum of the distances is 791, and the difference between the columns of northing and southing is .4, also the first distance is 70; say then,

791 : 70 : : .4 : .04,

which fourth proportional .04 is the first correction belonging to the southing 53.6, from which the correction .04 should be subtracted.

In this manner the several corrections of the southings

$$\left.\begin{array}{r}53.6\\29.1\\135.7\end{array}\right\}\text{ are found to be }\left\{\begin{array}{l}.04\\.09\\.07\end{array}\right\}\text{ respectively.}$$

But as only two of these corrections amount to half a tenth, we must use .1 for each of the corrections .09 and .07, and neglect the correction .04; thus the correct southings become 53.6, 29.0, 135.6.

In like manner from the remaining distances we obtain to

$$\text{the northings }\left\{\begin{array}{r}62.9\\101.1\\54.0\\00.0\end{array}\right\}\text{ the additive corrections }\left\{\begin{array}{l}.04\\.06\\.03\\.07\end{array}\right.$$

And consequently, by neglecting .04 and .03, and using .1 for each of the two .06 and .07, the northings when corrected are 62.9, 101.2, 54.0, 00.1.

In obtaining these corrections, it is commonly unnecessary to use all the significant figures of the distances: thus, for the ratio of 791 to 70, we may say, as 80 to 7.

The latitudes and departures being thus balanced, proceed to insert the meridian distances by the above method, where we still make use of the same field-notes, only changing chains and links into perches and tenths of a perch. Then by looking along the column of departure, it is easy to observe, that in the columns of eastings opposite station 9 all the eastings may be added, and the westings subtracted, without altering the denomination of either. Therefore, by placing 46.0, the east departure belonging to this station, in the column of meridian distances, and proceeding to add the eastings and subtract the westings, according to the rule already mentioned, we shall find that at station 8 these distances will end in 0, 0, or a cipher, if the additions and subtractions be rightly made. Then multiplying the upper meridian distance of each station by its respective northing or southing, the product will give the north or south area, as in the examples already insisted on, and which is fully exemplified in the annexed specimen. When these products are all made out and placed in their respective columns, their difference will give double the area of the plot, or twice the number of acres contained in the survey. Divide this remainder by 2, and the quotient thence arising by 160 (the number of perches in an acre), then will this last quotient exhibit the number of acres and perches contained in the whole survey; which in this example may be called 110 acres, 103 perches, or 110 acres, 2 roods, 23 perches.

FIELD-NOTES of the two foregoing methods, as practised in Pennsylvania.

Cast up by perches and tenths of a perch.

N.	Courses.	Dist.	N.	S.	E.	W.	M. D.	N. Area.	S. Area.
1	N 75° 00' E	54.8	14.2		52.9		235.3 288.2	3341.26	
2	N 20.30 E	41.2	38.6		14.4		302.6 317.0	11680.36	
3	East.	64.8			64.8		381.8 446.6		
4	S 33.30 W	141.2		117.7		77.9	368.7 290.8		43395.99
5	S 76.00 W	64.0		15.5		62.1	228.7 166.6		3544.85
6	North.	36.0	36.0				166.6 166.6	5977.60	
7	S 84.00 W	46.4		4.9		46.1	120.5 74.4		590.45
8	N 53.15 W	46.4	27.8			37.2	37.2 00.0	1034.16	
9	N 36.45 E	76.8	61.5		46.0		46.0 92.0	2829.00	
10	N 22.30 E	56.0	51.7		21.4		113.4 134.8	5862.78	
11	S 76.45 E	48.0		11.0	46.7		181.5 228.2		1996.50
12	S 15.00 W	43.4		41.9		11.2	217.0 205.8		9092.30
13	S 16.45 W	40.5		38.8		11.7	194.1 182.4		7531.08
			229.8	229.8	246.2	246.2		30745.16	66151.17 30745.16
								2	35406.01
								Area in perches	177030.05

Note.—In the foregoing methods the first meridian passes through the map; but as it is more convenient to have it pass through the extreme east or west point of the same, I have given the following example to illustrate this method.

Of computing the area of a survey by having the bearings and distances given, geometrically considered and demonstrated.

Let *BCDEFGHA*, pl. 14, fig. 11, represent the boundary of a survey of which the following field-notes are given; it is required to find the area.

EXAMPLE.

Sides of the land.	Bearings.	Length in chains.
BC	East.	4.00
CD	N 9° E	4.00
DE	S 69 E	5.58
EF	S 36 E	7.00
FG	S 42 W	4.00
GH	S 75 W	10.00
HA	N 39 W	7.50
AB	N 42 E	5.00

RULE I.

Find the difference of latitude and departure answering to each course and distance by the Traverse Table or right-angled plane trigonometry, according to the directions already given, and place them under the succeeding columns North or South, East or West, according as they are north or south, east or west; then if the survey does not close, correct the errors by saying,* as the sum of all the distances is to each

* This arithmetical rule was given by Mr. Bowditch in his solution of Mr. Patterson's question of correcting a survey in No. 4 of the Analyst. Also, the editor, Dr. Adrain, has given precisely the same practical rule,

particular distance, so is the whole error in departure to the correction of the corresponding departure, each correction being so applied as to diminish the whole error in departure: pro-

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in his elegant solution of the said question, analytically demonstrated. As the demonstration of this important rule may give great satisfaction to those who have not an opportunity of seeing the Analyst, I have inserted Mr. Bowditch's demonstration of said rule, which is as follows, viz.

Demonstration 1. That the error ought to be apportioned among *all* the bearings and distances.

2. That in those lines in which an alteration of the measured distance would tend considerably to correct the error of the survey, a correction ought to be made; but when such an alteration would not have that tendency, the length of the line ought to remain unaltered.

3. In the same manner, an alteration ought to be made in the observed bearings, if it would tend considerably to correct the error of the survey, otherwise not.

4. In cases where alterations in the bearings and distances will both tend to correct the error it will be proper to alter them both, making greater or less alterations according to the greater or less efficacy in correcting the error of the survey.

5. The alterations made in the observed bearing and length of any one of the boundary lines ought to be such that the combined effect of such alterations may tend wholly to correct the error of the survey.

Suppose now that $ABCDE$ (pl. 14, fig. 12) represent the boundary lines of a field, as plotted from the observed bearings and lengths, and that the last point E, instead of falling on the first A, is distant from it by the length AE. The question will then be, what alterations BB', CC'', DD''', &c. must be made in the positions of the points B, C, D, &c. so as to obtain the most probable boundaries $AB'C''D'''A$? If AB' be supposed to be the most probable bearing and length of the first boundary line, the point B would be moved through the line BB', and the following points C, D, E would in consequence thereof be moved in equal and parallel directions to C', D', E', and the boundary would become $AB'C'D'E'$. Again, if by correcting in the most probable manner the error in the observed bearing and length of BC (or $B'C'$), the point C' be moved to C'', the points D' and E' would be moved in equal and parallel directions to D'' and E'', and the boundary line would become $AB'C''D''E''$. In a similar manner, if by correcting the probable error in the bearing and length of CD (or $C''D''$) the point D'' be moved to D''', the point E'' would be moved in an equal and parallel direction to E''', and the boundary would become $AB'C''D'''E'''$. Lastly, by correcting the probable error in the bearing and length of the line DE (or $D'''E'''$) the true boundary $AB'C''D'''A$ would be obtained. If we suppose the lines $BB'CC''DD'''$, &c. to be parallel to AE, it would satisfy the second, third, fourth, and fifth of the preceding principles. For the change of position of the points B, C, &c. being in directions parallel to AE, the whole tendency of such change would be to move the point E directly towards A, conformably to the fifth principle; and by inspecting the figure, it will appear that the second, third, and fourth principles would also be satisfied. For, in the first place, it appears that the bearing of the first line AB would be altered considerably, but the length but little. This is agreeable to those principles, because an increase of the distance AB would move the point E in the direction Eb parallel to AB, and an alteration in the bearing would move it in the direction Eb' perpendicular to

ceed the same way for the corrections in latitudes. These corrections being applied to their corresponding differences of latitude and departure, that is, add when of the same name and

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AB. Now the former change would not tend effectually to decrease the distance AE, but the latter would be almost wholly exerted in producing that effect. Again, the length of the line BC would be considerably changed without altering essentially the bearing; the former alteration would tend greatly to decrease the distance AE, but the latter would not produce so sensible an effect. Similar remarks may be made on the changes in the other bearings and distances, but it does not appear to be necessary to enter more largely on this subject.

It remains now to determine the proportion of the lines BB', CC'', DD''', &c. To do this we shall observe, that in measuring the lengths of any lines the errors would probably be in proportion to their lengths. These supposed errors must, however, be decreased on those lines where the effect in correcting the error of the survey would be small, by the second and fourth principles.

In observing the bearings of all the boundary lines equal errors are liable to be committed; however, it will be proper, by the third and fourth principles to suppose the error greater or less in proportion to the greater or less effect it would produce in correcting the error of the survey.

Now the error of an observed bearing being given, as for example GFI (pl. 14, fig. 13), the change of position GI of the end of the line G would be proportional to the length of the line FG ($=FI$), so that the supposed errors both in the length and in the bearing of any boundary line would produce changes in the position of the end of it proportional to its length. There appears, therefore, a considerable degree of probability in supposing the lines BB', $C'C''$, $D'D'''$, &c. to be respectively proportional to the lengths of the boundary lines AB, BC, CD, &c. The main point to be ascertained before adopting this hypothesis is, whether a due proportion of the error of the survey is thrown on the bearings and lengths of the sides. Now it is plain by this hypothesis that the error in any boundary line is supposed to be wholly in the bearing if the line be perpendicular to AE, and wholly in its length when parallel to AE; and if the length be the same in both cases, the change of position of the end of the line would in both cases be exactly equal. Thus, if FGH be the boundary line, GI the change of position of the point B in the former case, and GH in the latter, we should in this hypothesis have $GI=GH$.

To show the probability of this hypothesis it may be observed, that in measuring the lengths of a line FGH of six or eight chains of fifty links each, an error of one link might easily be committed by the stretching of the chain or the unevenness of the surface. This error would be about $\frac{1}{350}$ of the whole length. If we, therefore, suppose GI to be $\frac{1}{350}$ of FG, the angle GFI would be about 10′. Now, with such instruments as are generally made use of by surveyors, it is about as probable that an error of 10′ was made in the bearing as that the above error, $\frac{1}{350}$ part, was made in measuring the length. We shall therefore adopt it as a principle, that the most probable way of apportioning the error of the survey AE is to take BB', $C'C''$, $D''D'''$, &c. respectively proportional to the boundary lines AB, BC, CD, &c.

Hence the following practical rule for correcting a survey *geometrically*. Draw the boundary lines $ABCDE$ by means of the observed bearings and

subtract when of different names, then the corrected difference of latitude and departure will be obtained, and the table will stand thus:

TABLE I.

Sids.	Courses.	D.Ch.	N.	S.	E.	W.	C.S.	C.W.	N.	S.	E.	W.
BC	East.	4.00			4.00		.02	.02		.02	3.98	
CD	N 9° E	4.00	3.95		0.63		.02	.02	3.98		0.61	
DE	S 69 E	5.56		1.99	5.19		.03	.02		2.02	5.17	
EF	S 36 E	7.00		5.66	4.11		.C5	.03		5.71	4.08	
FG	S 42 W	4.00		2.97		2.68	.02	.02		2.99		2.70
GH	S 75 W	10.00		2.59		9.66	.06	.05		2.65		9.7
HA	N 39 W	7.50	5.82			4.72	.05	.04	5.77			4.7
AB	N 42 E	5.00	3.72		3.35		.03	.02	3.69		3.33	
			13.49	13.21	17.28	17.06	.28	.22	13.39	13.39	17.17	17.17
			13.21		17.06							
			.28 Er. S.		.22 Er. W.							

lengths, and find the error of the survey *AE*, and let the quotient of *AE* divided by the sum of all the lines *AB*, *BC*, *CD*, *DE* be represented by *r*; through the angular points *B*, *C*, *D*, &c. draw the lines *BB'*, *CC''*, &c. parallel to *AE*, and in the same direction that *A* bears from *E*. Take $BB'=r\times AB$, $CC''=r\times(AB+BC)$, $DD'''=r\times(AB+BC+CD)$, &c.

The errors being corrected thus

As 47 : 4 : : .28 : .02
As 47 : 4 : : .28 : .02
&c. &c.
} The corrections of difference of lat. as in Table I.

As 47 : 4 : : .22 : .02
As 47 : 4 : : .22 : .02
&c. &c.
} The corrections of departure as in Table I.

The latitudes and departures being thus balanced, it is necessary to calculate the several meridian distances, in order to compute the area of the survey.

As beginning at the most easterly or most westerly point of the survey admits of a continual addition of the one and subtraction of the other, the most easterly or most westerly point can be easily discovered from the foregoing table, thus:

The first departure corrected is 3.98, which is the meridian distance of the second point of the survey from the first, to which add 0.61 the next dep. corrected, and their sum is 4.59, the meridian distance of the third points of the survey from the first; and in like manner $4.59+5.17=9.76=$ the meridian distance of the fourth point from the first, and $9.76+4.08=13.84$ $=$ the meridian distance east of the fifth point from the first; after the same manner, continue to add the dep. when east, but subtract when west: the next dep. is west, therefore $13.84-2.70=11.14=$ the meridian distance of the sixth point from the first, and $11.14-9.71=.43=$ the next. Now the next departure is 4.76, which is west, and 1.43 is the meridian distance of the seventh point from the first, which is east; therefore $4.76-1.43=3.33=$ the meridian distance of the eighth point from the first; as 3.33 is the greatest meridian distance west of the eighth point of the survey from the first, because the next departure is east 3.33; then, $3.33-3.33=0$, which closes the survey: consequently, the eighth point of the survey is the most westerly point, and for the same reason as 13.84 is the greatest meridian distance east, which is the meridian distance of the fifth point of the survey. In like manner, the most easterly or

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Then through the points A, B', C'', D''', &c. draw the corrected boundary lines $ABCDA$, which being determined, the area may be found by dividing the figure into triangles in the usual method.

The proportional parts BB', CC'', &c. may be found expeditiously by means of a table of difference of latitude and departure, by finding the page where the sum of the lines $AB+BC+CD+DE$ in the distance column corresponds to AE in the departure or difference of latitude column; then find AB, $AB+BC$, &c. in the distance column, and the corresponding numbers will be equal to BB', CC'', DD''', &c. respectively.

most westerly point of the survey can be found by beginning at any other point.

After the most easterly or most westerly point of the survey is discovered, call that point the first station, and proceed to find the meridian distances for the several lines in the order in which they were surveyed; that is, the first dep. will be the first meridian distance, which place in the column of meridian distances opposite the said departure; to the same meridian distance add the said departure, to which sum add the next departure if it be of the same name with the foregoing departure, but subtract if it be of a different name, which sum or difference call the next meridian distance, and set it in the column of meridian distances opposite the departure last used; and in like manner, continue to add the departure twice when of the same name, but if of a different name subtract twice, and the last meridian distance will be zero, if the additions and subtractions are rightly performed; because the sum of the northings is equal to the sum of the southings after the survey is corrected, which is evident from theo. 1, and the foregoing table. Then,* multiplying the upper meridian distance of each station by the corresponding northing or southing, and place the product in the north or south area, according as the latitude is north or south, the difference of the sum of these products will give twice the area, half of which gives the area of the survey.

The most westerly point of the survey being made the first station, and the several meridian distances being calculated, &c., the foregoing table will stand thus:

* Demonstration. Let NS be a meridian passing through the most westerly station from the points B, C, D, E, F, G, and H; let fall the perpendiculars Bb, Cb, Dd, Ec, Fe, Gf, and HI, on the meridian NS.

Now, if from the area of the figure $dDEFGHI$ the area of the figure $dDCBAHI$ be taken, there remains the area of the survey. The area of the multangular figure $dDEFGHI$ is equal to the sum of the areas of the trapezoids of which it is composed, viz. $dDEc$, $cEFe$, $eFGf$, and $fGHI$; but (by prob. 10), $(dD+cE)\times dc=$ twice the area of the trapezoid $dDEc$; and $dD+cE$ equal to the sum of the meridian distances of the points D and E from the first meridian line NS, and dc or $dg=$ the southing of the point E from the point D. In like manner the area of every other trapezoid is found: but these are the south column areas: that is, $(dD+cE)\times dc+(cE+eF)\times ce+(eF+fG)\times ef+(fG+IH)\times fI=$ twice the area of the figure $dDEFGHI=$ the sum of the south area column. And, in like manner, we demonstrate that $(dD+bC)\times db+bB\times bA+AI\times IH=$ twice the area of the figure $dDCBAHI=$ the north area column; therefore, $(dD+cE)\times dc+(cE+eF)\times ce+(eF+fG)\times ef+(fG+IH)\times fI-[(dD+bC)\times db+bB\times bA+AI\times IH]=$ twice the area of the survey; consequently, the sum of the south area column $-$ the sum of the north area column $=$ twice the area of the survey. Q. E. D.

TABLE II.

St.	Courses.	D. C.	N.	S.	E.	W.	C. S.	C. W.	N.	S.	E.	W.	M. D.†	N. Area.	S. Area.
1*	N 42° E	5	3.72		3.35		.03	.02	3.69		3.33		3.33 6.66	12.2875	
2	East.	4			4.00		.02	.02		.02	3.98		10.64 14.62		.2128
3	N 9 E	4	3.95		0.63		.02	.02	3.93		0.61		15.23 15.84	59.8530	
4	S 60 E	5.56		1.99	5.19		.03	.02		2.02	5.17		21.01 26.16		42.4402
5	S 36 E	7		5.66	4.11		.05	.03		5.71	4.08		30.26 34.34		172.7646
6	S 42 W	4		2.97		2.68	.02	.02		2.99		2.70	31.64 28.94		94.6036
7	S 75 W	10		2.59		9.66	.06	.05		2.65		9.71	19.23 9.52		50.9595
8	N 39 W	7.50	5.82			4.72	.05	.04	5.77			4.76	4.76 0.00	27.4652	

99.6066 361.0007
99.6066
2)261.3939
Area 13A. 0R. 11P 10)130.69695 S. C
13.069695
4
0.278780
40
1.151200

RULE II.‡

The difference of latitude and departure being found and corrected as in the preceding rule.

* This is not the first station in the actual survey, but only the most westerly point of the survey as calculated by the foregoing method from the field-notes, which, for convenience' sake, I call the first station in making out this table.

† The meridian distances in this column are the sum of two adjacent meridian distances; but at the most westerly point the meridian distance is nothing, hence the first dep. is the first meridian distance, and, in like manner, the last dep. is the last meridian distance.

‡ Demonstration. Let us consider that every tract of land has an extreme southerly point, as H; and we reckon so much as any other point is distant from the east and west line IK (Pl. 14, fig. 11), that passes through

As beginning at the most northerly or most southerly point of the survey admits of a continual addition of the one and subtraction of the other, make choice of either of these points in order to calculate the area of the survey.

1. It is necessary to calculate the several latitudes in order to find the most northerly or most southerly point of the survey, which may be done from Table I., thus:

The first lat. is .02 south, which is the difference of latitude between the second point of the survey and the first, when the survey is corrected from the next departure 3.93, which is N., subtract .02 and their difference 3.91 is equal to the difference of latitude between the third point and the first, which is N., and 3.91—2.02=1.89 = the difference of lat. between the fourth point and the first; which is also N. But as the next difference of lat. is south, therefore 5.71—1.89=3.82 = the difference of lat. S. between the fifth point and the first; and 3.82+2.99=6.81= the difference of lat. S. between the sixth point and the first; and 6.81+2.65=9.46 = the difference of lat. S. between the seventh point and the first; and 9.46—5.77=3.69 = the difference of lat. S. between the eighth point and the first; and 3.69—3.69=0; hence it is evident that 9.46 is the greatest lat. S. = the difference of lat. between the seventh point and the first; therefore, the seventh point of the survey is the most southerly point; and, in like manner, 3.91 = the difference of lat. between the third point and the first, is the greatest lat. N.; hence, the third point is the most northerly point of the survey.

H, to be its latitude north, or the difference of latitude between the points *H* and *A*; *BL* the lat. of *B*; *CM* the lat of *C*; &c.

Thus, if from the contents of the figure *IABCDEFK*, the contents of the figure *FKIAHG* be subtracted, the remainder will be the area of the survey.

The multangular figure *IABCDEFK* is composed of all these trapezoids, viz. *IABL*, *BCML*, *CDNM*, *EOND*, and *FKOE*; but (by Prob. 10) $(IA+LB)\times IL$ = twice the area of the trapezoid *IABL*, and $(LB+CM)\times LM$ = twice the area of the trapezoid *BCML*, and so for the rest; and $IA+LB$ = the sum of the northings of the points *A* and *B* from the line *IK*, and *IL* = the easting of the point *B* from the point *A*. In like manner the area of every other trapezoid is found; but these are the east column areas, that is, $(IA+BL)\times IL+(BL+CM)\times LM+(CM+DN)\times MN+(DN+EO)\times NO+(EO+FK)\times OK$ = twice the area of the figure *IABCDEFK* = the sum of the east area column. And in like manner we demonstrate that $(FK+PG)\times PK$ = twice the area of the trapezoid *FKPG*; but $FK+PG$ = the lat. of $F+$ the lat. of *G* and *PK* = the dep. or westing of the point *G* from the point *F*, and $PG\times PH$ = twice the area of the triangle *PGH*, and $IA\times IH$ = twice the area of the triangle *IAH*; hence $(FK+PG)\times PK+PG\times PH+IA\times IH$ = twice the area of the figure *FKIAGH* = the sum of the west area column. Therefore $(IA+BL)\times IL+(BL+CM)\times LM+(CM+DN)\times MN+(DN+EO)\times NO+(EO+FK)\times OK-[(FK+PG)\times PK+PG\times PH+IA\times IH]$ = twice the area of the survey; consequently, the sum of the east area column — the sum of the west area column = twice the area of the survey. Q. E. D.

Now, by calling the most southerly point of the survey the first station, and proceeding to find the latitudes for the several lines in the order in which they were surveyed; that is, the first difference of lat. will be the first lat., which place in the column of latitudes, opposite the said difference of latitude; to the same lat. add the said difference of lat., to which sum add the next difference of lat. if it be of the same name, but subtract if of a different name, and place it in the column of latitudes; in like manner continue to add or subtract the difference of lat. twice, and the last lat. comes out nothing, if the additions and subtractions are rightly performed. Multiply each of the upper numbers in the column of latitudes by the corresponding dep., and place the products in the column of east or west area, according as the dep. is E. or W. The difference of these columns will be equal to twice the area, half of which will give the area of the survey; as in the following table.

TABLE III.

St.	Courses.	D. C.	N.	S.	E.	W.	c. s.	c.w.	N.	S.	E.	W.	Lat.	E. Area.	W. Area.
1	N 39° W	7.50	5.83			4.72	.05	.04	5.77			4.76	5.77 11.54		27.4662
2	N 42 E	5	3.72		3.35		.03	.02	3.69		3.33		15.23 18.92	50.7159	
3	East.	4			4.00		.02	.02		.02	3.98		18.90 18.88	75.2290	
4	N 9 E	4	3.95		0.63		.02	.02	3.93		0.61		22.81 26.74	13.9141	
5	S 69 E	5.56		1.99	5.19		.03	.02		2.02	5.17		24.72 22.70	127.8094	
6	S 36 E	7		5.66	4.11		.05	.03		5.71	4.08		16.99 11.28	60.3192	
7	S 42 W	4		2.97		2.68	.02	.02		2.99		2.70	8.29 5.30		22.3530
8	N 75 W	10		2.59		9.66	.06	.05		2.65		9.71	2.65 0.00		25.7315
														336.9736	75.5797

336.9736
75.5797
2)261.3939
10)130.69695
13.069695 Acres.

Ans. 13A. 0R. 11P.

Each of the numbers in the column of latitudes is twice the mean latitude of two adjacent latitudes; but at the most southerly point the latitude is nothing; hence the first difference of latitude is the first lat., and in like manner the last difference of lat. is the last latitude. It is also to be remarked that the first station used in this table is not the first station in the actual survey, but the most southerly point of the survey, as calculated by the foregoing method from Table I.

SECTION IV.

OF OFFSETS.

In taking surveys it is unnecessary and unusual to make a station at every angular point, because the field-work can be taken with much greater expedition by using offsets and intersections, and with equal certainty; especially where creeks, &c. bound the survey.

Offsets are perpendicular lines drawn or measured from the angular points of the land, that lie on the right or left-hand to the stationary distance, thus:

Pl. 11. *fig.* 2.

Let the black lines represent the boundaries of a farm or township; and let 1 be the first station: then if you have a good view to 2, omit the angular points between 1 and 2, and take the bearing and length of the stationary line 1, 2, and insert them in your field-book; but in chaining from 1 to 2, stop at *d* opposite the angular point *a*, and in your field-book insert the distance from 1 to *d*, which admit to be 4*ch.* 25*l.*, as well as the measure of the offset *ad*, which admit to be 1*ch.* 12*l.*, thus: by the side of your field-book, in a line with the first station, say at 4*ch.* 25*l.* L. 1*ch.* 12*l.*, that is, at 4*ch.* 25*l.* there is an offset to the left-hand of 1*ch.* 12*l.*

This done, proceed on your distance line to *e* opposite to the angle *b*, and measure *eb*; supposing then 1*e* to be 7*ch.* 40*l.*, and *eb* 3*ch.* 40*l.*, say (still in a line with the first station in your field-book) at 7*ch.* 40*l.* L. 3*ch.* 40*l.*, that is, at 7*ch.* 40*l.* there is an offset to the left of 3*ch.* 40*l.*; proceed then with your distance line to *f* opposite to the angle *c*, and measure *fc*; suppose then 1*f* to be 13*ch.* and *fc* 1*ch.* 25*l.*, say, in the same line as before, at 13*ch.* L. 1*ch.* 25*l.* Then proceed from *f* to 2, and you will have the measure of the entire stationary line 1, 2, which insert in its proper column by the bearing.

In taking offsets, it is necessary to have a perch chain, or a staff of half a perch, divided into links for measuring them; for by this means the chain in the stationary line is undisturbed, and the number of chains and links in that line from whence, or to which, the offsets are taken, may be readily known.

Having arrived at the second station, if you find your view will carry you to 3, take the bearing from 2 to 3, and in measuring the distance line, stop at *l* opposite *g*; admit 2*l* to be 4*ch.* 10*l.*, and the offset *lg* 1*ch.* 20*l.*, then in a line with the second station in your field-book, say at 4*ch.* 10*l.* R. 1*ch.* 20*l.*, that is, the offset is a right-hand one of 1*ch.* 20*l.* Again, at *m*, which suppose to be 10*ch.* 25*l.* from 2, take the offset *mh* of 1*ch.* 15*l.*, and in a line with the second station, say at 10*ch.* 25*l.* R. 1*ch.* 15*l.* In the same line, when you come to the boundary at *i*, insert the distance 2*i*, 13*ch.* 10*l.*, thus, at 13*ch.* 10*l.* 0; that is, at 13*ch.* 10*l.* there is no offset. At *n*, which is 15*ch.* from 2, take the offset *nk* 45*l.*, and still opposite to the second station say at 15*ch.* L. 45*l.*

Let the line 3, 6 represent the boundary which by means of water, briers, or any other impediment, cannot be measured. In this case make one or more stations within or without the land, where the distances may be measured, and draw a line from the beginning of the first to the end of the last distance, thus: make stations at 3, 4, and 5, take the bearings, and measuring the distances as usual, which insert in your field-book, and draw a mark like one side of a parenthesis, from the third to the fifth station, to show that a line drawn from the third station to the farthest end of the fifth stationary line will express the boundary. Thus,

No. Sta.	Deg.	*ch. l.*
3	172½	5.45
4	200	13.25
5	250	3.36

Suppose the point *p* of the boundary to be inaccessible by means of the lines 6*p* or *p*7 being overflowed, or that a quarry, furze, &c. might prevent your taking their lengths: in this case take the bearing of the line 6, 7, which insert opposite to the sixth station in your field-book with the other bearing; then direct the index to the point *p*, and insert its bearings on the left side of the field-book, opposite to the sixth station, annexing thereto the words *Int. for boundary;* and having measured and inserted the distance 6, 7, set the index in the direction of the line 7*p*, and insert its bearing on the left of the seventh station

of the field-book, annexing thereto the words *Int. for boundary*: the crossing or intersection of these two bearings will determine the point *p*, and of course the boundary 6*p*7 is also determined.

If your view will then reach in the first station, take its bearing, stationary line, and offsets as before, and you have the field-book completed. Thus,

The Field-book.

Remarks and Inter.	N. St.	Deg.	*ch. l.*	OFFSETS.
318 Int. to a tower	1	358	22.12	At 4*ch.* 25*l.* L. 1*ch.* 12*l.* at 7*ch.* 40*l.* L. 3*ch.* 40*l.* at 13*ch.* L. 1*ch.* 25*l.*
231½ Int. to ditto	2	297¾	22.12	At 4*ch.* 10*l.* R. 1*ch.* 20*l.* at 10*ch.* 25*l.* R. 1*ch.* 51*l.* at 13*ch.* 10*l.* 0. at 15*ch.* L. 45*l.*
	3	172¼	5.45	
	4	200	13.25	
	5	250	3.36	
155½ Int. for bound.	6	125	15.15	At 1*ch.* 20*l.* L. 2*ch.* 20*l.* at 7*ch.* 45*l.* L. 2*ch.* 32*l.* at 11*ch.* 25*l.* 0. at 12*ch.* 25*l.* R. 36*l.*
274 Int. for ditto.	7	105¼	15.10	

Close at the first station.

If you would lay down a tower, house, or any other remarkable object in its proper place, from any two stations take bearings to the object, and their intersection will determine the place where you are to insert it, in the manner that the tower is set out in the figure, from the intersection taken at the first and second stations of the above field-book.

A protraction of this will render all plain, on which lay off all your offsets and intersections, and proceed to find the contents by any of the methods in section the fourth.

The foregoing Field-book may be otherwise kept, thus:

Remarks and Intersection.	No. St.	Deg.	L. hand Offset. *ch. l.*	Dist. *ch. l.*	R. hand Offset. *ch. l.*
318 Int. to a tower -	1	358	1.12	4.25	
			3.40	7.40	
			1.25	13.00	
				22.12	
232½ Int. for ditto - -	2	297¾		4.10	1.20
				10.25	1.15
				13.10	
			0.45	15.00	
				21.21	
	3	172½		5.45	
	4	200		13.25	
	5	250		3.36	
155½ Int. for boundary	6	125		15.15	
274 Int. for boundary	7	105	2.20	1.20	
			2.32	7.45	
				11.25	
				12.25	0.36
				15.10	

How to cast up offsets by the pen.

PL. 11. *fig.* 2.

$1, 2-1f=2f$, $2f-1e=fe$, $1e-1d=ed$.

Then $1d\times\frac{1}{2}da=1da$, and $ed\times\frac{1}{2}(da+eb)=beda$, $\frac{1}{2}(eb+fc)\times fe=befc$, and $2f\times\frac{1}{2}fe=cf2$; the sum of all which will be $1abc21$; the area contained between the stationary line 1, 2 and the boundary $1abc2$.

In the same manner you may find the area of $2ihg2$, of $ik3i$, as well as what is without and withinside of the stationary line 7, 1.

If therefore the left-hand offsets exceed the right-hand ones, it is plain the excess must be added to the area within the sta tionary lines; but if the right-hand offsets exceed the left-hand ones the difference must be deducted from the said area, if the

ground be kept on the right-hand, as we have all along supposed; or in words thus:

To find the contents of offsets.

1. From the distance line take the distance to the preceding offset, and from that the distance of the one preceding it, &c. in four-pole chains; so will you have the respective distances from offset to offset, but in a retrograde order.

2. Multiply the last of these remainders by half the first offset, the next by half the sum of the first and second, the next by half the sum of the second and third, the next by half the sum of the third and fourth, &c. The sum of these will be the area produced by the offsets.

Thus, in the foregoing field-book the first stationary line is 22*ch.* 12*l.*, or 11*ch.* 12*l.* of four-pole chains. See the figure.

	ch. l.	*ch. l.*	*ch. l.*
From	11.12=1,	6.50=1*f*	3.90=1*e*
Take	6.50=1*f*	3.90=1*e*	2.25=1*d*
	4.62=2*f*	2.60=*ef*	1.65=*ed*

ch. l.	
1*d*=2.25 × 32*l.*, half the first offset,	.7200
ed =1.65 × 1*ch.* 26*l.*, half the sum of the 1st and 2d, =	2.0790
ef =2.60 × 1*ch.* 32*l.*, half the sum of the 2d and 3d, =	3.4320
2*f*=4.62 × 37*l.*, half the last offset, =	1.7094
Contents of left offsets on the first distance in square four-pole chains,	7.9404

In like manner the rest are performed.

The sum of the left-hand offsets will be	14.0856
And the sum of the right-hand ones	3.6825
Excess of left-hand offets in sq. four-pole chains,	10.4031
Acres	1.04031
	.16124
	4
Perches	6.4496

Excess of left-hand offsets above the right-hand ones, 1A. 0R. 6P., to be added to the area within the stationary lines.

SECTION V.

To find the area of a piece of ground by intersections only, when all the angles of the field can be seen from any two stations on the outside of the ground.

PL. 12. *fig.* 1.

Let *ABCDEFG* be a field, *H* and *I* two places on the outside of it from whence an object at every angle of the field may be seen.

Take the bearing and distance between *H* and *I*; set that at the head of your field-book, as in the annexed one. Fix your instrument at *H*, from whence take the bearings of the several angular points *ABCD*, &c. as they are here represented by the lines *HA*, *HB*, *HC*, *HD*, &c. Again, fix your instrument at *I* and take bearings to the same angular points, represented by the lines *IA*, *IB*, *IC*, *ID*, &c., and let the first bearings be entered in the second column and the second bearings in the third column of your field-book; then it is plain that the points of intersection made from the bearings in the second and third columns of every line will be the angular points of the field, or the points *A*, *B*, *C*, *D*, &c., which points being joined by right lines will give the plan *ABCDEFGA* required.

Bear. 180, Dist. 28*ch.* of the Sta. *H* and *I*.

No.	Bear.	Bear.
A	261½	331½
B	265¾	317¼
C	248	307½
D	238¼	289
E	215½	262½
F	208½	286½
G	220	300

The same may be done from any two stations withinside of the land from whence all the angles of the field can be seen.

This method will be found useful in case the stationary distances from any cause prove inaccessible, or should it be required to be done by one party when the other, in whose possession it is, refuses to admit you to go on the land.

To find the contents of a field by calculation, which was taken by inter section.

In the triangle *AIH*, the angles *AHI*, *AIH*, and the base *HI* being known, the perpendicular *Aa* and the segments of the base *Ha*, *AI* may be obtained by trigonometry: and in the same manner all the other perpendiculars, *Bb*, *Cc*, *Dd*, *Ee*, *Ff*, *Gg*, and the several segments at *b*, *c*, *d*, *e*, *f*, *g*: if, therefore, the several perpendiculars be supposed to be drawn into the scheme (which are here omitted, to prevent confusion arising from a multiplicity of lines), it is plain that if from *bBCDEeb* there be taken *bBAGFeb* the remainder will be the map *ABCDEFGA*.

As before, half the sum of *Bb* and *Cc* multiplied by *bc* will be the area of the trapezium *bBCc*; after the same manner, half the sum of *Cc* and *Dd* multiplied by *cd* will give the area of the trapezium *cCDd*; and again, half the sum of *Dd* and *Ee* multiplied by *de* gives the area of the trapezium *dDEe*; and the sum of these three trapezia will be the area of the figure *bBCDEeb*.

Again, in the same manner, half the sum of *Bb* and *Aa* mul tiplied by *ab* will give the area of the trapezium *BbAa*, and half the sum of *aA* and *gG* by *ag* gives the trapezium *aAGg*; to these add the trapezia *gGFf* and *fFEe*, which are found in the like manner, and you will have the figure *bBAGFEeb*, and this taken from *bBCDEeb* will leave the map *ABCDEFGA*. Q. E. I.

It will be sufficient to protract this kind of work, and from the map to determine the area as well as in plate 10, fig. 3, to find the areas of the pieces 3, 4, 5, 6, 3 and 6, 7, 7, 6 from geometrical constructions.

How to determine the station where a fault has been committed in a field-book, without the trouble of going round the whole ground a second time.

From every fourth or fifth station, if they be not very long ones, or oftener if they are, let an intersection be taken to any object, as to any particular part of a castle, house, or cock of hay, &c., or, if all these be wanting, to a long staff with a white sheet or napkin set thereon, to render the object more conspicuous, and let this be placed on the summit of the land, and let the respective intersections so taken be inserted on the left-hand side of the field-book opposite to the stations from whence they were respectively taken.

In your protraction as you proceed let every intersection be laid off from the respective stations from whence they were taken, and let these lines be continued; if they all converge or

meet in one point, we thence conclude all is right, or so far as they do converge; but if we find a line of intersection to diverge or fly off from the rest, we may be sure that either a mistake has happened between the station the foregoing intersection was taken at and the station from whence the intersection line diverges, or there must be an error in the intersection; but to be assured in which of these the fault is, protract on to the next intersection, and having set it off, if it converges with the rest, though the foregoing one did not, we may conclude the fault was committed in taking the last intersection but one, and none in any station, and that so far is true as is protracted; but if this as well as the foregoing intersection diverge or fly from the point of côncourse or converging point of the rest, the error must have its rise from some station or stations at or after that from whence the last converging intersection line was taken: so that by going to that station on the ground, and proceeding on to that where the next or from whence the following diverging intersection was taken, we can readily and with little trouble set all to rights.

But in most tracts of land one object cannot be seen from every station, or from perhaps one-fourth of them; in this case we are under the necessity to move the pole after we begin to lose sight of it, to some other part of the land, where it may be seen from as many more stations as possible; which is easily done by viewing the boundary before it be surveyed: the pole then being fixed in an advantageous place, the first intersection to it is best to be made from the same station from whence the last one was taken, and then as often as may be thought convenient, as before; in like manner the whole may be done by the removal of the pole.

When we here speak of stations, we do not mean such as are usually taken at every particular angle of the field: for it is to be apprehended, that every skilful surveyor, particularly such who use calculation, will take the longest distances possible, not only to lessen the number of stations, for the ease of either protraction or calculation, but with greater certainty to account for the land passed by, on the right-hand or on the left, which is taken by offsets: and surely it will be allowed that any measure taken on the ground, and the contents thence arithmetically computed, will be much more accurate than that which is obtained from any geometrical projection.

From what has been said it is plain, that from this method any fault committed in a survey can be readily determined, and therefore must be much preferable to the present method of taking diagonals, or the bearings and lengths of lines across

land, to accomplish that end; which last method is too frequently used by surveyors to approximate or arrive near the contents, which will ever remain uncertain, let these diagonals be ever so many, till the station or stations wherein the error or errors were committed be found; and the fault or faults be corrected.

Where one diagonal is taken, it may perhaps close or meet with one part of the survey and not with the other; in this case, if the surveyor would discover his error, he must survey that part of the land which did not close, and this may be half or more of the whole. And should the diagonal close with neither part, but be too long or too short, or should it fall on either side of the assigned point it was to close with, he ought to go over the whole, and make a new survey of it, in order to discover his error.

A number of diagonals are frequently taken, the sum of the lengths of which very often exceeds the circuit of the ground, and after all they are but approximations, and the contents remain uncertain as before; therefore, he who returns a map made up by the assistance of diagonals, where there remains a misclosure in any one part, runs the risk of being detected in an error, and must suffer uneasiness in his mind, as he cannot be certain of the return he makes.

The frequent misclosures which are botched up by diagonals occasion the many and frequent scandalous broils and animosities between surveyors, which tend to the loss of character of the one or the other, and indeed often to the disrepute of both, as well as to that of the science they profess.

But these may be easily remedied by intersections and the bearing or line to be adjusted where the fault was committed; and till this be found, nothing can be certain.

SECTION VI.

TO ENLARGE OR DIMINISH MAPS.

To enlarge or diminish a map, or to reduce a map from one scale to another; also, the manner of uniting separate maps of lands which join each other into one map of any assigned size.

Lay the map you would enlarge over the paper on which you would enlarge it, and with a fine protracting pin prick through every angular point of your map; join these points on your paper (laying the map you copy before you) by pencilled

or popped lines, and you have the copy of the map you are to enlarge: in this manner any protraction may be copied on paper, vellum, or parchment, for a fair map.

If you would enlarge a map to a scale which is double, or treble, or quadruple to that of the map to be enlarged, the paper you must provide for its enlargement must be two, or three, or four times as long and broad as the map; for which purpose in large things you will find it necessary to join several sheets of paper, and to cement them with white wafer or paste, but the former is best.

Then pitch upon any point in your copied map for a centre; from whence if distances be taken to its extreme points, and thence if those distances be set in a right line with (but from) the centre, and these last points fall within your paper, the map may be increased on it to a scale as large again as its own; and if the like distances be again set outwards in right lines from the centre, and if these last points fall within your paper, it will contain a map increased to a scale three times as large as its own, &c.

PL. 12. *fig.* 2.

Let the pricked or popped lines represent the copy of a down or old survey, laid down by a scale of 80 perches to an inch, and let it be required to enlarge it to one laid down by 40 to an inch.

Pitch upon your centre as ⊙, from whence through *a* lay the fiducial edge of a thin ruler; with a fine-pointed pair of compasses take the distance from *a* to the centre ⊙, and lay it by the ruler's edge from *a* to *A*; in the like manner take the distance from the next station *b* to the centre ⊙, and lay it over in a right line from *b* to *B*, and join the points *A* and *B* by the right line *AB*; in the like manner set over the distance from every station to the centre, from that station outwards, and you will have every point to enlarge to: the joining of these constantly as you go on by right lines will give you the enlarged map required.

In taking the distance from every station to the centre, set one foot of the compasses in the station, and the other very lightly over the centre-point, so lightly as scarcely to touch it, otherwise the centre-point will become so wide, that it may occasion several errors in the enlarged map: for if you err from the exact centre but a little, that error will become double, or treble, or quadruple, as you enlarge to a scale that is double, or treble, or quadruple of the given one; therefore great accuracy is required in enlarging a map.

When you have done with a station, give a dash with a pen or pencil to it, such as at the station *a* and *b*: by this means you cannot be disappointed in missing a station, or in laying your ruler over one station twice.

From what has been said it is plain, that if a map is to be enlarged to one whose scale is double the given one, that the distances from the respective stations to the centre, being set over by the ruler's edge, will give the points for the enlarged one. And thus may a map be enlarged from a scale of 160 to one of 80, from one of 80 to one of 40, from one of 20 to one of 10 perches to an inch, &c. For to enlarge to a scale that is double, the number of perches to an inch for the enlarged map must be half of those to an inch for that to be enlarged: to enlarge to a scale that is treble the given one, the number of perches to an inch for the enlarged map will be one-third of those for the other; if to a scale that is quadruple the given one, the number of perches to an inch for the enlarged map will be one-fourth of those for the other, &c.: therefore, if you would enlarge a map which is laid down by a scale of 120 perches to an inch to one of 40 perches to an inch, the distance from the several stations to the centre, being set twice beyond the said stations, will mark out the several points required, for these points will be three times farther from the centre than the stationary points of the map are.

In the same manner, if you would enlarge a map from a scale of 160 to one of 40 perches to an inch, the distance from the several stations to the centre, being set three times beyond said stations, will lay out the points for your enlarged map, for these points will be four times farther from the centre than are the stations of the map.

When a map is enlarged to another, whose scale is double, or treble, or quadruple, &c. of the given one, every line, as well as the length and breadth of the enlarged map, will be double, or treble, or quadruple, &c. those of the given one, for it must be easy to conceive that those maps are like: but the area if the scale be double will be four times, if treble nine times, if quadruple sixteen times that of the given figure; that is, it will contain four, nine, or sixteen times as many square inches as the given one (for it has been shown that like polygons are in a duplicate proportion with the homologous sides). Yet these figures being cast up by their respective scales will produce the same contents.

Thus much is sufficient for enlarging maps, and from hence, diminishing of them will be obvious; for one-fourth, one-third, or half the distances from the several stations to the centre

will mark out points which if joined will compose a map similar to the given one, whose scale will be four times, three times, or twice as small as the given one.

Thus, if we would reduce a map of from 40 to 80, from 20 to 40, from 10 to 20 perches to an inch, &c., half the distance of the stations from the centre will give the points requisite for drawing the map; if we would reduce from 40 to 120, from 20 to 60, from 10 to 30 perches to an inch, &c., one-third of the distances to the centre will give the points for the map; and if we would reduce from 40 to 160, from 20 to 80, from 10 to 40 perches to an inch, &c., one-fourth of the distances to the centre will give the points for the map.

By the methods here laid down I have reduced a map from a scale of 40 to one of 20 perches to an inch, which contained upwards of 1200 acres, and consisted of 224 separate divisions, without the least confusion from the lines; for none can arise if the methods here laid down be strictly observed.

I have also from the same methods reduced a large book of maps, each of which was an entire skin of parchment, and the whole contained upwards of 46,000 acres, to a pocket volume; and afterward connected all these maps into one map, which was contained in one skin of parchment: therefore, upon the whole I do recommend these methods for reducing maps to be much more accurate than any of the methods commonly used, such as squaring of paper, using a parallelogram, proportionable compasses, or any other method I ever met with, though the figures to be reduced were ever so numerous, irregular, or complicated.

To unite separate maps of lands which join each other into one map of any assigned size.

If there be several large maps contained in a book, each of which suppose to take up a skin of parchment, or a sheet of the largest paper, which maps of lands join each other, and it be required to reduce them to so small a scale that all of them when joined together may be contained in one skin, half a skin, or any assigned sized piece of parchment or paper:—

Having pricked off and copied the several maps on any kind of paper, unite them by cutting with scissors along the edge of one boundary which is adjoining the other, but not cutting by the edge of both, and throw aside the parts cut off: then lay these together on a large table, or on the floor, and where the boundaries agree they will fit in with each other as indentures do; and after this manner they are easily connected: measure then the length and breadth of the entire connected maps, and

the length and breadth of the parchment or paper you are confined to; if the former be three, four, or five times greater (that is, longer and broader) than the latter, reduce each copied map severally to a scale that is three, or four, or five times less, as before; and the same parts of the boundaries you cut by in the large maps, by the same you must also cut in small ones, and unite the small as the large ones were united; cementing them together with white wafer: thus your map will be reduced to the assigned size, which copy over fair on the parchment or paper you were confined to.

But it is not always that a person is confined to a given area of parchment, or paper; in such cases, if there are many large maps to be united into one, reduce each of them severally to a scale of 160 perches to an inch, and unite those by the contiguity or boundaries, as before: or if you have a few, it will be sufficient to reduce them to a scale of 120, &c. But having the maps given, and the scale by which they are laid down, your reason will be sufficient to direct you to know what scale they should be reduced to.

Directions concerning surveys in general.

If you have a large quantity of ground to survey, which consists of many fields or holdings, and that it be required to map and give the respective contents of the same, it is best to make a survey of the whole first, and to be satisfied that it is truly taken, as well as to find its contents; and as you go round the land, to make a note on the side of your field-book at every station where the boundary of any particular field or holding intersects or meets the surround; then proceed from any one of those stations, and in your field-book say, "proceed from such a station," and when you have gone round that field or division, insert the station you close at, and so through the whole: a little practice only can render this sufficiently familiar, and the method of protraction must be evident from the field-notes. When the whole is protracted, and you are satisfied of the closes of the particular divisions, cast up each severally, and if the sum of their contents be equal to the contents of the whole first found, you may safely conclude that all is right.

The protraction being thus finished and cast up, transfer it on clean paper, vellum, or parchment as before; be careful to draw your lines with a fine pen, write on it the names of the circumjacent lands, and set No. 1, 2, 3, 4, &c. in every particular field or division; let every tenant's particular holding be distinguished by a different coloured paint being run finely along the boundaries; let all the roads, rivulets, rivers, bogs, ponds,

houses, castles, churches, beacons, or whatever else may be remarkable on the ground, be distinguished on the map. Write the title of the map in a neat compartment, either drawn or done from a good copper-plate engraving, with the gentleman's arms. Prick off one of your parallels with the map, and on it make a mariner's compass, and draw a flower-de-luce to the north, and this will represent the magnetical north; after which set off the variation, which express in figures, and through the centre of the compass let a true meridian line be drawn of about 3 inches long, by which write True Meridian. Let a scale be drawn, or it is sufficient to express the number of perches to an inch the map was laid down by. Draw a reference table of three or, if occasion be, of four or more columns: in the first insert the number of the field or holding; in the next its name, and by whom occupied; in the third the quantity of acres, roods, and perches it contains; if you have unprofitable land, as bog or mountain, let the quantity be inserted in the fourth column; and if it be required, you may make another column for statute measure, and then the map is completed.

SECTION VII.

THE METHOD OF DIVIDING LAND, OR OF TAKING OFF OR ENCLOSING ANY GIVEN QUANTITY.

EXAMPLE I.

Pl. 12. *fig.* 1.

Let *ABCD*, &c. be a map of ground containing 11 acres; it is required to cut off a piece, as *DEFGID*, that shall contain 5 acres.

Join any two opposite stations, as *D* and *G*, with the line *DG* (which you may nearly judge to be the partition line), and find the area of the part *DEFG*, which suppose may want 3R. 20P. of the quantity you would cut off; measure the line *DG*, which suppose to be 70 perches. Divide 3R. 20P., or 140P., by 25, the half of *DG*, and the quotient 4 will be a perpendicular for a triangle whose base is 70 and area 140P. Let *HI* be drawn parallel to *DG*, at the distance of the perpendicular 4, and from *I*, where it cuts the boundary, draw a line to *D*, and that line *DI* will be the division line; or a line from *G* to *H*

will have the same effect; all which must be evident from what has been already said.

But if hills, trees, &c. obstruct the view of the points *D* and *I* from each other, it will be necessary, in order to run a partition line, to know its bearing; and it may be proper on some occasions to have its length; both these may be easily calculated from the common field-notes only, as in the following example, without the trouble of any other measurement on the ground, or any dependence on the map and scale.

EXAMPLE II.

Pl. 12. *fig.* 3.

Let *ABCDEFGHIA* be a tract of land to be divided into two equal parts by a right line from the corner *I* to the opposite boundary *CD*; required the bearing and length of the partition line *IN*, by calculation, from the following field-notes, viz.

Field-Notes and Area.

Bound.	Bearing.	Perch.
AB	N 19° 0′ E	108
BC	S 77 0 E	91
CD	S 27 0 E	115
DE	S 52 0 W	58
EF	S 15 30 E	76
FG	West.	70.9
GH	N 36 0 W	47
HI	North.	64.3
IA	N 62 15 W	59
152A. 1R. 25.9P.		

Operation.

IABCI		Per.	N.	S.	E.	W.	Merid. dist. &c.
IA	N 62¼° W	59	27.5	—	—	52.2	
AB	N 19 E	188	102.1	—	35.2	—	
BC	S 77 E	91	—	20.5	88.7	—	
CI	—— —	—	—	109.1	—	71.7	
Area, 8722.3 perches.			129.6	129.6	123.9	123.9	

152A. 1R. 25.9P. =24385.9 perches.
Half, to be divided off, =12192.9 } subtract.
The part *IABCI* = 8722.3 }

Triangle *ICNI* = 3470.6 perches.

ICDI.		Per.	N.	S.	E.	W.	Meridian dist. &c.
IC	N — E	115	109.1	—	71.9	—	
CD	S 27 E	—	—	102.5	52	—	
DI				6.6	—	123.9	
Area 6522.1 per.			109.1	109.1	123.9	123.9	

Then, as { *ICDI* : *CD* : : *ICNI* : *CN* / 6522.1 : 115 : : 3470.6 : 61.19 } theo. 18, sec. 1, which determines the point *N* in *CD*.

ICNI.		Per.	N.	S.	E.	W.
IC	as before	—	109.1	—	71.7	
CN	S 27° E	61.2	—	54.6	27.8	—
NI			—	—	—	—
	————	—	—	54.6	—	99.5

As dif. lat.	54.6		As S. Bear.	61° 15′
: Radius S.	90°		: Depart.	99.5
: : Depart.	99.5		: : Radius S.	90°
: Tang. Bear.	61° 15′		: Distance	113.49

Answer, { *IN* runs N. 61° 15′ E. / *NI* runs S. 61 15 W. } 113.5 perches.

In the part *IABCI*, the difference between the northings and the southings of the three lines *IA*, *AB*, and *BC* (109.1) is the difference of latitude, and that of their eastings and westings (71.7) the departure of the line *CI*, which is placed thereto, so as to balance the columns; see theo. 1, sect 5: hence the contents are obtained, as already taught, without the bearing or length of the line *CI*.

For the triangle *ICDI*, the dif. lat. and dep. of *IC* are taken from the preceding table, which in going from *I* to *C*

will be northing and easting: those of CD are found by the bearing and distance, and of DI by balancing the columns, as before for CI.

The difference of latitude (54.6) and departure (99.5) of the line NI, in the third table, are found by balancing those of IC and CN; and as they are the base and perpendicular of a right-angled triangle, of which the line NI is the hypothenuse, and the angle opposite to the departure the bearing, we have the answer by two trigonometrical statings, as above; and thus may any tract be accurately divided, or any proposed quantity readily cut off or enclosed.

Now the student or practitioner may calculate the contents of the part $ABCNIA$ (the bearing and distance, or the dif. lat. and dep. of CN and of NI being known), and if it be found equal to the intended quantity, it proves the truth of the operation.

EXAMPLE III.

PL. 12. *fig.* 3.

It is proposed to cut off 38A. 16¼P. to the south end of this tract, by a line running from E due west 40 perches to a well at O, and from thence a right line to a point M in the boundary HI; the place of M and the bearing and length of the line OM are required, the field-notes being as in example second.

$$\text{Answer, } \left\{ \begin{array}{l} M \text{ from } H, \text{ north } 43.23 \\ OM, \text{ N. } 78^\circ\ 7'\ \text{W. } 39.03 \end{array} \right\} \text{ perches.}$$

In this example we find,

$$\left. \begin{array}{lr} \text{The area of } OEFGHO & =5270.5 \\ \text{Consequently of } HOMH & =\ 826.0 \\ \text{Dif. lat. of the line } HO=HV & =\ 35.2 \\ \text{Departure of ditto } =OV & =\ 38.2 \end{array} \right\} \text{ perches.}$$

As HI happens to be a meridian, the area of $HOMH$ divided by half OV (19.1) quotes HM (42.23), without finding the area of $HOIH$, as we did of $ICDI$ in example second, and $HM-HV=VM=8.03=$ dif. lat. of OM, which with its dep. $VO=38.2$, gives the bearing and distance as before.

EXAMPLE IV.

PL. 12. *fig.* 4.

A trapezoidal field $ABCD$, bounded as under specified, is to be divided into two equal parts by a right line EF parallel to AB or CD; required AF or BF.

Bou.	Bearing.	Per.
AB	South.	30
BC	N 80° W	60
CD	N 39½ W	45.5
DA	S 80 E	89.4
13A. 3R. 7P.		

In the triangle *CBG* are given *BC* and all the angles (known by the bearings) to find *BG*, and thence the area by prob. 9, sect. 4. which, + half the area of *ABCD* = area of *EFG*; then, as the area of *CBG* is to that of *EFG*, so is the square of *BG* to the square of *FG*, and *FG*—*BG*=*BF*

Operation at large.

Angle *G* 39° 30′, log. S. Co. Ar.	0.19649	add
Side *BC* 60 per. log.	1.77815	
Angle *C* 40° 30′, sine	9.81254	
Side *BG* 61.26 per.	1.78718	add
Side *BC* 60 per.	1.77815	
Angle *B* 100° 0′, sine	9.99335	
2)3619.8, log.	3.55868	
As *CBG*=1809.9 Co. Ar.	6.74235	add
1103.5=*BCEF*		
Is to *EFG*=2913.4, log.	3.46440	
So is sq. *BG* 61.26, log.	1.78718	
	1.78718	
To sq. *FG* 77.72,	2)3.78111	
Ans. *BF*=16.46 perches	1.89055	

By the application of this method a tract of land may be divided accurately, in any proportion, by a line running in any assigned direction.

Note.—When the practitioner would wish to be very accurate, it will be much better to work by four-pole chains and links than by perches and tenths; one-tenth of a perch square being equal to 6¼ square links.

EXAMPLE V.

The following Field-notes (from A. Burns*) are of a piece of land, which is proposed, as an example, to be divided into three equal parts by two right lines running from the sixth and seventh stations: and proved by calculating the contents of the middle part.*

St.	Bearing.	4-P. *ch.*
1	N.E. 56¼°	21.60
2	N.E. 26½	13.44
3	S.E. 71½	18.96
4	S.E. 26½	13.44
5	S.W. 71½	18.96
6	S.E. 45	8.47
7	S.E. 63½	13.44
8	N.E. 45	8.47
9	S.E. 26½	13.44
10	S.W. 45	8.47
11	S.W. 63½	13.44
12	N.W. 76	24.73
13	N.W. 36¾	30.00
Area, 167A. 1R. 24P.		

EXAMPLE VI.

Pl. 8. *fig.* 5.

The plot *ABCDEFGHA* is proposed to be divided *geometrically*, in the proportion of 2 to 3, by a right line from a given point in any boundary or angle thereof, suppose the point *D*.

Reduce the plot to the triangle *cDe*, as already taught; divide the base *ce* in the point *N*, so that *cN* be to *Ne* in the ratio of 2 to 3, by prob. 14; draw *DN*, and it is done.

EXAMPLE VII.

PL. 12. *fig.* 3.

Example second may likewise be performed geometrically.

Produce CD both ways for a base, and reduce the whole to a triangle, making I the vertical point; then bisect the base in N, and draw IN. But,

Notwithstanding this geometrical method is demonstrably true in theory, it is not as safe, on practical occasions requiring accuracy, as the calculation, even when performed with the greatest care; for which reason we will not enlarge on it here.

EXAMPLE VIII.

Suppose 864 *acres to be laid out in form of a right-angled parallelogram, of which the sides shall be in proportion as* 5 *to* 3; *required their dimensions.*

For the greater side, multiply the area by the greater number of the given proportion, and divide by the less, or, for the less side, multiply by the less number, and divide by the greater; the square root of the quotient will be the side required: thus,

864A.=138240P.	1.38240
5	3
3)691200	5)414720
Ans. $\sqrt{230400}=480$.	$\sqrt{82944}=288$

EXAMPLE IX.

If it be required to lay out any quantity of ground, suppose 47A. 2R. 16P., in form of a parallelogram, of which the length is to exceed the breadth by a given difference, for instance, 80 perches, then add the square of half this difference to the area, and take the square root of the sum; to which add half the difference for the greater side, and subtract it therefrom for the less: thus,

2)80	47A. 2R. 16P.=7616 perches.
40	1600
40	$\sqrt{9216}=96$
1600 half diff.;	add and subt. 40

$$\text{Ans.}\begin{cases}\text{the length}=136\\ \text{the breadth}=56\end{cases}$$

Any proposed quantity of ground may be laid out or enclosed in the form

Of a	Square	by prob. 2d,	sec. 4.
	Parallelogram, one side given,	by prob. 4th,	
	Triangle of a given base, .	by prob. 7th,	
	Circle	by prob. 13th,	

It is sometimes most convenient, when land is to be laid out adjacent to a creek, river, or other crooked boundary, to measure offsets to the angles or bending thereof, from a right line or lines taken near such boundary, and to deduct the area of these offsets from the given quantity, and then to lay off the remainder from the right line or lines, in the desired form.

In laying out new lands, attention must be paid to the allowance for roads, as exemplified in prob. 14th.

SECTION VIII.

OF SURVEYING HARBOURS, SHOALS, SANDS, &c.

PL. 13. *fig.* 1.

THERE are three methods whereby this may be performed; for the observations may be made either on the water or on the land. Those made on the water are of two kinds; one by the log-line and compass (as in plane sailing measuring) the course and distance round the sand; and then to be plotted as a large wood, or any enclosure taken by the circumferentor.

This method I omit, for two reasons: first, because it is to be deduced from the writers of navigation; and, secondly, because the distances thus measured are liable to the errors of currents, which generally attend shoals or sands near the shore.

The second method, when there are no distances to be measured on the water, though still there is one inconvenience, common also to the former, because the bearings or observations are to be taken on that unstable element (an error scarce mentioned by practical artists), I shall briefly hint at; and so rather choose a third, which is liable to neither of these imperfections.

Let a boat be manned out with a signal flag, a log and line, lead and line, and, to observe the bearings of any landmark, a compass with sights.

Take two or more objects or places, as *A*, *B*, *C*, on the

shore, from whence the boat may be seen on the several parts of this shoal, and determine their relative position by bearing and distances either before or after the other necessary observations are made.

One of the boat's crew is to sound till he finds himself on the edge of the sand, by the depth of water, and then to come to an anchor; which he is to signify to two persons on the shore at *B* and *C*, by his signal. And then from those known landmarks *B* and *C* the observers are to take the bearings of the boat, and to register their observations; which, when done, they are to signify to the crew by waving a flag, or by some other signal.

And in the mean time, to prevent mistakes, let the crew take the bearings of each of these landmarks: then weigh anchor, which suppose at *D*.

Then, by sounding, proceed to *E*, and make like observations. And so at *E*, *F*, *G*, &c., till you have surrounded your sand.

And if in the process you are about to lose the sight of one of your landmarks, suppose *C*, let your assistant at *C*, or *B*, who at that time will also be about to lose the sight of the boat, by signals (before agreed on) remove to some other object beforehand agreed on, suppose to *H* or *K*, and then to proceed as before.

Lastly, if the sand runs so far out at sea that the object cannot be seen by the boat, nor the boat by the observer on shore, there may be rockets fired by the boat's crew, and also by the observers on the shore in the night, whereby those bearings may be taken almost at as great a distance as the light can be seen. For supposing they rise but a quarter of a mile above the apparent horizon, its stay will be about 9 seconds, and its distance for this quarter of a mile will be visible about 44 miles.

But rockets rise much higher, and then the distances are much greater whereby they are visible.

Or two boats may lay at anchor, instead of the landmarks, and then you may work as before.

Now since the landmarks *B* and *C* are fixed, their position may be laid down in the draught, as in common surveying, by plotting the distance between *B* and *C*. And then by plotting the line *BD*, and the line *DC*, according to their position, their common intersection will give the point *D*. And in like manner *E*, *F*, *G*, &c. may be plotted; and so the shoals completed. And this from the bearings taken at *B* and *C*.

If this be a standing lake, environed by bogs, or other impediments, the observations at *D*, *E*, *F*, &c., by taking their

opposites, may suffice to plot the same from the landmarks, *A*, *B*, *C*, &c. as well as those taken on the land: or, indeed, by the course and distance, as in navigation, if the water be smooth and without a current.

In sea shoals, it is convenient to note at each observation the depth of the water found by the lead, and the drift and setting of the current by the log and compass, while the boat is at anchor, which may be done with ease and expedition enough. For while the boat rides at an anchor, her stern points out the setting of the current, and the log and glass will measure its drift.

And these ought to be noted on the draught, which may be thus:

The currents may be shown, by drawing a dart pointing out its setting, and its drift by the Roman capital letters, the depth of the water by the small figures, and rocks by little crosses, &c.

SECTION IX.

OF LEVELLING.

PL. 13. *fig.* 2.

LEVELLING is the art of ascertaining the perpendicular ascent or descent of one place (or more) above or below the horizontal level of another, for various intentions, and of marking out courses for conveyance of water, &c.

The *true level* is a curve conforming to the surface of the earth; as *ABG*.

The *apparent level* is a tangent to that curve; as *ADE*.

The *correction* or allowance for the earth's curvature is the difference between the apparent level and the true; as *BD*. The quantity of this correction may be known by having in the right-angled triangle *CAD* the two legs *AC* = the semidiameter of the earth (=1267500 perches), and *AD* = the distance of the object, to find the hypothenuse *CD*, from which taking *CB* (=*CA*), the remainder will be the correction *BD*; but it may be obtained more practically thus:

$$\begin{array}{l}\text{Square the}\\ \text{distance in}\end{array}\left\{\begin{array}{lr}\text{four-pole chains, and divide by} & 800,\\ \text{or in perches, and divide by} & 12800\\ \text{or in miles, and multiply by} & 8\end{array}\right\}\begin{array}{l}\text{for the cor-}\\ \text{rection in}\\ \text{inches.}\end{array}$$

EXAMPLE.

Required the correction for 20 four-pole chains = 80 perches = ¼ mile.

800)20 × 20=400(.5
12800)80 × 80=6400(.5
¼=.25, and .25 × .25 × 8=.5.

That is, .5, or ½ inch, the correction required.

But, to save the trouble of calculation, we insert the following table of corrections.

A Table of Corrections.
The distances in four-pole chains.

Distan.	Correc.	Distan.	Correc.
Chains.	Inches.	Chains.	Inches.
1	0.00125	27	0.91
2	0.005	28	0.98
3	0.01125	29	1.05
4	0.02	30	1.12
5	0.03	31	1.19
6	0.04	32	1.27
7	0.06	33	1.35
8	0.08	34	1.44
9	0.10	35	1.53
10	0.12	36	1.62
11	0.15	37	1.71
12	0.18	38	1.80
13	0.21	39	1.91
14	0.24	40	2.00
15	0.28	45	2.28
16	0.32	50	3.12
17	0.36	55	3.78
18	0.40	60	4.50
19	0.45	65	5.31
20	0.50	70	6.12
21	0.55	75	7.30
22	0.60	80	8.00
23	0.67	85	9.03
24	0.72	90	10.12
25	0.78	95	11.28
26	0.84	100	12.50

The first thing necessary in levelling is the adjusting of the level, which may be performed several ways. The following is very easy and practical.

Choose some ground which is not above 4 or 5 feet out of the level, for the distance of 8 or 10 chains in length, and suppose it be *AB* (fig. 3), and find the middle between *A* and *B*, which suppose to be *C*; plant the intstrument at *C*, direct the tube to a station-staff held up at *A*, and elevate or depress the tube till the bubble is exactly in the middle of the divisions; then by signals direct your assistant at *A* to raise or depress the vane sliding on the station-staff till the horizontal hair in the glass cuts the middle of that vane; then see how many feet, inches, and parts are cut by the upper part of the vane, which suppose to be 3 feet 4 inches and 6 tenths.

In like manner direct to the other staff at *B*, and suppose the upper edge of that vane to be cut at the height of 6 feet 5 inches and 2 tenths, then will these two vanes be on a level.

From 6 feet 5.2 inches subtract 3 feet 4.6 inches, and reserve the remainder 3 feet 0.6 inches.

Now remove the instrument as close to the higher station-staff as you can; so that the middle of the telescope may almost touch it. Then bring the telescope as near to a level as the judgment of the eye will direct.

Measure from the ground the height of the top of the telescope; and also of the bottom in feet, inches, and parts; suppose them to be 4 feet 10.5 inches, and 5 feet 0.3 inches; then half the sum of the heights 4 feet 11.4 inches is the height of the centre of the glass; and to this add half the breadth of the vane, which suppose to be 1 inch and 5 tenths, and to the sum 5 feet 0.9 inches add the preceding remainder 3 feet 0.6 inches; then let the person at *B* move his vane till the upper edge cut 8 feet 1.5 inches, the sum of the preceding numbers.

Now so elevate or depress the hair of the bubble till the hair cut the middle of the vane at *B*, and at the same time the bubble stands at the middle of the divisions; and then will the instrument be duly adjusted.

If you have a mind to be more accurate, repeat the operation; but when you place the instrument at *C*, turn the tube at right angles to the line *AB*, and there set it level; then proceed with a repetition of the work. Only observe to cross-level it in this adjustment, and in all future uses whatsoever.

Or the level may be adjusted thus: As before, first plant the instrument in the middle between *A* and *B* (fig. 4), and observe the heights on the station-staves, which suppose to be as above; and consequently their difference, as before, is 3 feet 0.6 inches. Now measure from *C* towards the highest ground

4, some distance that comes almost to *A*, suppose 4 chains to *D*; and *DB* will be 9 chains, and *DA* one chain; then plant the instrument at *D*, direct the telescope to *A*, and setting the bubble to the middle of the division direct your assistant to move the vane till the hair cuts the middle of it, and note down the feet, inches, and parts cut by the upper edge of the vane, which suppose to be 3 feet 8.4 inches: to this add the difference 3 feet 0.6 inches, and the sum 6 feet 9 inches reserve.

Now direct the telescope to the staff at *B*, level it, and direct your assistant to move the vane till the hair cuts the middle thereof; and then if the upper edge of the vane cuts the foregoing sum 6 feet 9 inches, the hair and bubble are truly adjusted. But if not, say, as *BD* less *AD* is to the difference between the numbers cut by the upper edge of the vane and the number 6 feet 9 inches, so is the distance *AD* to a number which, added to that cut by the vane when less than 6 feet 9, and subtracted from the number cut by the vane when it is greater than 6 feet 9, will give a number, to which let the assistant fix the vane; then so elevate or depress the hair or the bubble till the hair cuts the middle of the vane at *B*, and the bubble stands in the middle of the divisions; for then the level will be adjusted. The operation may be again repeated, and at every station cross-levelled, which will confirm the former adjustment.

Or it will be still better to set the station-staves equally distant from the instrument (suppose about 16 or 20 perches each) at an angle of about 60°, or so as to form nearly an equilateral triangle therewith, and level the two vanes (*A* and *B*, fig. 5), as before, which will be then both in the same horizontal level, whether the instrument be rightly adjusted or not, because one will be as much above or below the true level of the instrument as the other, being in the same distance from it; then remove the instrument as near as may be to one of them, suppose *A*, and raise or lower the vane *A* to the exact level of the visual ray in the instrument, noting precisely how much it is moved, and have the other vane *B* moved just as much, in order to bring them again to a level, allowing for the correction of the apparent level if it be a sensible quantity; then adjust the instrument to the level of the vane at *B*.

To adjust the rafter-level (plate 13, fig. 6), which may be 10, 12, or 14 feet in the span *AB*; set it on a plank or hard ground nearly level, and mark where the plumb line cuts the beam *mn*, suppose at *c*; then invert the position by setting the foot *A* in the place of *B*, and *B* in that of *A*, marking where the line now cuts, as at *e*; the middle point between *c* and *e* will be the true levelling mark.

To continue a level course with this instrument, set the foot *A* to the starting place, and move *B* upward or downward towards *D* or *E*, till the point *B* be determined and marked for a level with *A*; then carry the instrument forward in the direction of *C*, till the foot *A* rests at *B*, whence the point *C* is levelled as before, &c. Sights may be placed at *r* and *s*, and the instrument adjusted to them, as before, by reversing them in the direction of some distant object.

After the instrument is duly adjusted, you may proceed to use it. Let the example be this annexed (fig. 7), where *A* everywhere represents the level, and *B* the station-staves; and suppose the route be made from *a* to *e*: first plant the instrument between the staves *a* and *b*; at *A* direct the level to *aB*, bring the bubble to the middle of the divisions, and instruct your assistant so to place the vane that the hair in the telescope cuts the middle of the vane; then in a book divided into two columns, the one entitled *Back-sights*, the other *Fore-sights*, enter the feet, inches, and parts cut by the upper edge of the vane at *aB* in the column entitled *Back-sights*.

Then look towards the other staff *bB*, bring the bubble to the middle of the divisions, and direct your assistant to place the vane so that the hair cuts the middle of the vane; then enter the feet, inches, and parts cut by the upper edge of the vane in the column of *Fore-sights*.

Now plant the instrument at A^2, still keeping the staff *Bb* exactly in the same place, and carry the staff *aB* forward to the place *cB*; now look back to the staff *bB*, and enter the numbers cut by the vane there under the title *Back-sights*; then look forwards to *cB*, and enter the observation under the title *Fore-sights*. Do the like when the instrument is planted at A^3, A^4, &c., always taking care to keep the staff in the same place when you looked at it for a *fore-sight*, till you have also taken with it a *back-sight*.

Having finished your level, add up the column of *back-sights* into one sum, and the column of *fore-sights* also into one sum; and the difference between these sums is the ascent or descent required. And if the sum of the *fore-sights* be greater than the sum of the *back-sights*, then *e* is lower than *a*; but if the sum of the *fore-sights* be less than the sum of the *back-sights*, *e* is higher than *a*. For example, let the numbers be as in the following table.

Back-sights.			*Fore-sights.*		
Feet.	Inches.	Tenths.	Feet.	Inches.	Tenths.
3	7	5	6	4	5
4	6	8	8	3	2
6	0	2	5	4	7
9	5	0	8	7	8
1	0	7	9	4	8
24	8	2	38	1	0
			24	8	2

Hence the descent is { 13 . 4 . 8 / 13 . 4 . 8

Observations.

1. And if the distances thus taken are short, the curvature of the earth may be rejected. For, if the distance from the instrument be everywhere about 100 yards, all the curvatures in a mile's work will be less than half an inch.

2. If the distance from the instrument to the hindermost staff be everywhere equal to the distance from the instrument to the corresponding staff, the curvature of the earth and the minute errors of the instrument will both be destroyed. Hence it will be much better to set the instrument as equally distant from both staves as may be.

3. If the distances of the instrument from the staves be very unequal and very long, the curvatures must be accounted for, and the distances, in order thereto, must be measured.

4. Therefore it appears, that the best method to take a level is, to measure the several distances from the instrument to the back and forward station-staves; and enter them in the field-book, according to the titles of their several columns, as in the following example; and correct the heights from the table of allowances, which may be done at home when you are about to sum up the heights

Backwards.			Forwards.		
Distan.	Height.	Corrected.	Distan.	Height.	Corrected.
Links.	Inches.	Inches.	Links.	Inches.	Inches.
370	3.25	3.24	418	4.36	4.34
420	6.10	6.08	328	7.18	7.17
760	5.38	5.31	289	6.75	6.67
584	7.25	7.21	530	9.53	9.50
326	8.15	8.14	485	11.25	11.22
658	10.25	10.20	376	8.65	8.63
530	6.32	6.29	720	10.34	10.28
36.58		46.47	31.46		57.81
31.46					46.47
68.04					11.34

So that the fall in 68 chains is about 11 inches and $\frac{1}{3}$ of an inch.

Lastly, though hitherto we have considered the level with one telescope only, the same observations may be applied to a level with a double telescope; and I would advise those who use the double telescope, at every station to turn that end of the telescope forward which before was the contrary way.

A more general method of levelling, adapted to the surveying of roads and hilly ground, is exhibited in the following example, in which the measures are given in links.

EXAMPLE.

PL. 13. *fig.* 8.

Required the bearing and distance of the place *B* from *A*, and its perpendicular ascent or descent above or below the horizontal level of *A*.

St.	Course or Bearing.	Elevation or Depression.	Obl. Dist.	Hor. Dist.	Perpen. Ascent or Des.	Dif. Lat.	Depart.
1	N.E. 79° 15′	D. 17° 15′	738	705	218.9	131	692
2	N.E. 75 00	D. 21 45	684	635	253.4	164	613
3	N.E. 50 30	E. 14 00	976	947	236.1	602	730
4	S.E. 85 15	D. 11 30	930	911	185.4	75	908
5	S.E. 70 00	E. 19 15	620	585	204.0	200	549
			3948	3783	217.6 Desc.	622 N.	3492 E.

As dif. lat. 622
Is to radius S. 20°,
So is dep. 3492
To T. bear. 79° 54′.

As S. bear. 79° 45′
Is to dep. 3492,
So is radius S. 90°
To dist. 3547.

As 100 links : 66 feet : : 217.6 links : 143.6 feet, the descent *B* below the level of *A*.

Hence, *B* bears N. 79° 54′ E. from *A*.
Nearest horiz. dist. 3547 links.
Sum of obl. dist. 3948 links.
Sum of horiz. dist. 3783 links.
Perp. desc. 217.6 links = 143.6ft.
} Answer.

With the angular elevation or depression in the third column, and the oblique distance in the fourth (as course and distance) are found the horizontal distance in the fifth, and the perpendicular ascent or descent on the sixth, for each station (as difference of latitude and departure): then, with the bearing and horizontal distance, we get the difference of latitude and departure in the last two columns.

The ascents and descents in the sixth column are distinguished by the letters E and D in the third, signifying elevation or depression; and being added separately, the difference of their sums is set at the bottom of the column with the name of the greater, and shows the perpendicular descent of *B* below the horizontal level of *A*.

In like manner the northings and southings in the seventh column are distinguished by the letters N and S in the second, &c.

PROMISCUOUS QUESTIONS.

The perambulator, or surveying wheel, is so contrived as

to turn just twice in the length of a pole, or $16\frac{1}{2}$ feet; what then is the diameter? Ans. 2.626 feet.

2. Two sides of a triangle are respectively 20 and 40 perches; required the third, so that the contents may be just an acre. Ans. either 23.099 or 58.876 perches.

3. I want the length of a line by which my gardener may strike out a round orangery that shall contain just half an acre of ground. Ans. $27\frac{3}{4}$ yards.

4. What proportion does the arpent of France, which contains 100 square poles of 18 feet each, bear to the American acre, containing 160 square poles of 16.5 feet each, considering that the length of the French foot is to the American as 16 to 15? Ans. as 512 to 605.

5. The ellipse in Grosvenor Square measures 840 links the longest way, and 612 the shortest, within the rails: now the wall being 14 inches thick, it is required to find what quantity of ground it encloses, and how much it stands upon.

Ans. It encloses 4A. 6P., and stands on $1760\frac{1}{4}$ square feet.

6. Required the dimensions of an elliptical acre with the greatest and least diameters in the proportion of 3 to 2.

Ans. 17.479 by 11. 653 perches.

7. The paving of a triangular court at 18*d.* per foot, came to 100*l.* The longest of the three sides was 88 feet: what then was the sum of the other two equal sides?

Ans. 106.85 feet.

8. In 110 acres of statute measure, in which the pole is $16\frac{1}{2}$ feet, how many Cheshire acres, where the customary pole is 6 yards, and how many of Ireland, where the pole in use is 7 yards?

Ans. 92A. 1R. 28P. Cheshire; 67A. 3R. 25 P. Irish.

9. The three sides of a triangle containing 6A. 1R. 12P. are in the ratio of the three numbers 9, 8, 6, respectively; required the sides. Ans. 59.029, 52.47, and 39.353.

10. In a pentangular field, beginning with the south side, and measuring round towards the east, the first or south side is 2735 links, the second 3115, the third 2370, the fourth 2925, and the fifth 2220; also the diagonal from the first angle to the third is 3800 links, and that from the third to the fifth 4010; required the area of the field. Ans. 117A. 2R. 28P.

11. Required the dimensions of an oblong garden containing three acres, and bounded by 104 perches of pale fence.

Ans. 40 perches by 12.

12. How many acres are contained in a square meadow, the diagonal of which is 20 perches more than either of its sides?

Ans. 14A. 2R. 11P.

13. If a man six feet high travel round the earth, how much greater will be the circumference described by the top of his head than by his feet? Ans. 37.69 feet.

N. B.—The required difference is equal to the circumference of a circle 6 feet radius, let the magnitude of the earth be what it may.

14. Required the dimensions of a parallelogram containing 200 acres, which is 40 perches longer than wide.

Ans. 200 perches by 160.

15. What difference is there between a lot 28 perches long by 20 broad, and two others, each of half the dimensions?

Ans. 1A. 3R.

PART III.

Containing the astronomical methods of finding the latitude, variation of the compass, &c., with a description of the instruments used in these operations.

SECTION I.

INTRODUCTORY PRINCIPLES.

Day and night arise from the circumrotation of the earth. That imaginary line about which the rotation is performed is called the axis, and its extremities are called poles. That towards the most remote parts of Europe is called the *north pole*, and its opposite the *south pole*. The earth's axis being produced will point out the *celestial poles*.

The equator is a great circle on the earth, every point of which is equally distant from the poles; it divides the earth into two equal parts, called hemispheres: that having the north pole in its centre is called the *northern hemisphere*, and the other the *southern hemisphere*. The plane of this circle being produced to the fixed stars will point out the celestial equator, or equinoctial. The equator, as well as all other great circles of the sphere, is divided into 360 equal parts, called *degrees*; each degree is divided into 60 equal parts, called *minutes*; and the sexagesimal division is continued.

Note.—The ancients, having no instruments by which they could make observations with any tolerable degree of accuracy, supposed the length of the year, or annual motion of the earth, to be completed in 360 days: and hence arose the division of

the circumference of a circle into the same number of equal parts, which they called *degrees.*

The meridian of any place is a semicircle passing througu that place, and terminating at the poles of the equator. The other half of this circle is called the *opposite meridian.*

The latitude of any place is that portion of the meridian of that place which is contained between the equator and the given place; and is either *south* or *north,* according as the given place is in the northern or southern hemisphere, and therefore cannot exceed 90°.

The parallel of latitude of any place is a circle passing through that place parallel to the equator.

The difference of latitude between any two places is an arch of a meridian intercepted between the corresponding parallels of latitude of those places. Hence, if the places lie between the equator and the same pole, their difference of latitude is found by subtracting the less latitude from the greater; but if they are on opposite sides of the equator, the difference of latitude is equal to the sum of the latitudes of both places.

The first meridian is an imaginary semicircle, passing through any remarkable place, and is therefore arbitrary. Thus, the British esteem that to be the first meridian which passes through the royal observatory at Greenwich; and the French reckon for their first meridian that which passes through the royal observatory at Paris.—Formerly many French geographers reckoned the meridian of the island of Ferro to be their first meridian; and others, that which was exactly 20 degrees to the west of the Paris observatory. The Germans, again, considered the meridian of the Peak of Teneriffe to be the first meridian. By this mode of reckoning, Europe, Asia, and Africa are in east longitude, and North and South America in west longitude. At present the first meridian of any country is generally esteemed to be that which passes through the principal observatory, or chief city, of that country.

The longitude of any place is that portion of the equator which is contained between the first meridian and the meridian of that place; and is usually reckoned either *east* or *west,* according as the given place is on the east or west side of the first meridian; and, therefore, cannot exceed 180°.

The difference of longitude between any two places is the intercepted arch of the equator between the meridians of those places, and cannot exceed 180°.

There are three different horizons, the apparent, the sensible, and the true. The apparent or visible horizon is the utmost apparent view of the sea or land; the sensible is a plane

passing through the eye of an observer, perpendicular to a plumb-line hanging freely; and the true or rational horizon is a plane passing through the centre of the earth, parallel to the sensible horizon.

Altitudes observed at sea are measured from the visible horizon. At land, when an astronomical quadrant is used, or when observations are taken with a Hadley's quadrant by the method of reflection, the altitude is measured from the sensible horizon; and in either case the altitude must be reduced to the true horizon.

The zenith of any given place is the point immediately above that place, and is, therefore, the elevated pole of the horizon. The nadir is the other pole, or point diametrically opposite.

A vertical is a great circle passing through the zenith and nadir; and therefore intersecting the horizon at right angles.

The altitude of any celestial body is that portion of a vertical which is contained between its centre and the true horizon. The meridian altitude is the distance of the object from the true horizon, when on the meridian of the place of observation. When the observed altitude is corrected for the depression of the horizon and the errors arising from the instrument, it is called the *apparent altitude;* and when reduced to the true horizon, by applying the parallax in altitude, it is called the *true altitude.* Altitudes are expressed in degrees and parts of a degree.

The zenith distance of any object is its distance from the zenith, or the complement of its altitude.

The declination of any object is that portion of its meridian which is contained between the equinoctial and the centre of the object; and is either north or south according as the star is between the equinoctial and the north or south pole.

The ecliptic is that great circle in which the annual revolution of the earth round the sun is performed. It is so named because eclipses cannot happen but when the moon is in or near that circle. The inclination of the ecliptic and equinoctial is at present about 23° 28′; and by comparing ancient with modern observations, the obliquity of the ecliptic is found to be diminishing—which diminution, in the present century, is about half a second yearly.

The ecliptic, like all other great circles of the sphere, is divided into 360°; and is further divided into twelve equal parts, called signs: each sign, therefore, contains 30°. The names and characters of these signs are as follows:

Aries, ♈	Cancer, ♋	Libra, ♎	Capricornus, ♑
Taurus, ♉	Leo, ♌	Scorpio, ♏	Aquarius, ♒
Gemini, ♊	Virgo, ♍	Sagittarius, ♐	Pisces, ♓

Since the ecliptic and equinoctial are great circles, they therefore bisect each other in two points, which are called the *equinoctial points*. The sun is in one of these points in March, and in the other in September; hence, the first is called the *vernal*, and the other the *autumnal* equinox—and that sign which begins at the vernal equinox is called *Aries*. Those points of the ecliptic which are equidistant from the equinoctial points are called the *solstitial points;* the first the *summer*, and the second the *winter solstice*. That great circle which passes through the equinoctial points and the poles of the earth is called the *equinoctial colure;* and the great circle which passes through the solstitial points and the poles of the earth is called the *solstitial colure*.

When the sun enters Aries it is in the equinoctial, and therefore has no declination. From thence it moves forward in the ecliptic, according to the order of the signs, and advances towards the north pole, by a kind of retarded motion, till it enters Cancer, and is then most distant from the equinoctial; and moving forward in the ecliptic, the sun apparently recedes from the north pole with an accelerated motion till it enters Libra, and, being again in the equinoctial, has no declination; the sun, moving through the signs Libra, Scorpio, and Sagittarius, enters Capricorn; and then its south declination is greatest, and is therefore most distant from the north pole; and moving forward through the signs Capricorn, Aquarius, and Pisces, again enters Aries: hence a period of the seasons is completed, and this period is called a solar year.

The signs Aries, Taurus, Gemini, Cancer, Leo, and Virgo are called *northern signs*, because they are contained in that part of the ecliptic which is between the equinoctial and north pole; and, therefore, while the sun is in these signs, its declination is *north:* the other six signs are called *southern signs*. The signs in the first and fourth quarters of the ecliptic are called *ascending signs*, because while the sun is in these signs it approaches the north pole; and, therefore, in the northern, temperate, and frigid zones, the sun's meridian altitude daily increases; or, which is the same, the sun ascends to a greater height above the horizon every day. The signs in the second and third quarters of the ecliptic are called *descending signs*.

The tropics are circles parallel to the equinoctial, whose distance therefrom is equal to the obliquity of the ecliptic.

The northern tropic touches the ecliptic at the beginning of Cancer, and is therefore called the *tropic of Cancer;* and the southern tropic touches the ecliptic at the beginning of Capricorn, and is hence called the *tropic of Capricorn.*

Circles about the poles of the equinoctial, and passing through the poles of the ecliptic, are called polar circles; the distance, therefore, of each polar circle from its respective pole is equal to the inclination of the ecliptic and equinoctial. That circle which circumscribes the north pole is called the *arctic* or *north polar circle;* and that towards the south pole, the *antarctic* or *south polar circle.*

That semicircle which passes through a star, or any given point of the heavens, and the poles of the ecliptic, is called a circle of latitude.

The reduced place of a star is that point of the ecliptic which is intersected by the circle of latitude passing through that star.

The latitude of a star is that portion of the circle of latitude contained between the star and its reduced place; and is either *north* or *south,* according as the star is between the ecliptic and the north or south pole thereof.

The longitude of a star is that portion of the ecliptic contained between the vernal equinox and the reduced place of the star.

SECTION II.

Description of the instruments requisite in astronomical observations.

THE QUADRANT.

It is generally allowed that we are indebted to John Hadley, Esq. for the invention, or at least for the first public account, of that admirable instrument commonly called Hadley's quadrant, who in the year 1731 first communicated its principles to the Royal Society, which were by them published soon after in their Philosophical Transactions; before this period the cross-staff and Davis's quadrant were the only instruments used for measuring altitudes at sea, both very imperfect, and liable to considerable error in rough weather; the superior excellence, however, of Hadley's quadrant soon obtained its

general use among seamen, and the many improvements this instrument has received from ingenious men at various times have rendered it so correct, that it is now applied, with the greatest success, to the important purposes of ascertaining both the latitude and longitude at sea or land.

Figure 2, Frontispiece, represents a quadrant of reflection, the principal parts of which are, the octant or frame *ABC* (which is generally made of ebony, or other hard wood, and consists of an arch firmly attached to two radii or bars, which are strengthened and bound by the two braces in order to prevent it from warping), the graduated arch *BC*, the index *D*, the nonius or vernier scale *E*, the index glass *F*, the horizon glasses *G* and *H*, the dark glasses or screens *I*, and the sight vanes *K* and *L*.

The arch, or limb *BC*, although only the eighth part of a circle, is, on account of the double reflection, divided into 90 degrees, numbered 0, 10, 20, 30, &c., from the right towards the left: these are subdivided into three parts, containing each 20 minutes, which are again subdivided into single minutes, by means of a scale at the end of the index. The arch extending from 0 towards the right-hand is called the *arch of excess.*

The index *D* is a flat brass bar, that turns on the centre of the instrument; at the lower end of the index there is an oblong opening; to one side of this opening a nonius scale is fixed, to subdivide the divisions of the arch; at the bottom or end of the index there is a piece of brass which bends under the arch, carrying a spring to make the nonius scale lie close to the divisions; it is also furnished with a screw to fix the index in any desired position.

Some instruments have an *adjusting* or *tangent-screw*, fitted to the index, that it may be moved more slowly, and with greater regularity and accuracy than by the hand; it is proper, however, to observe, that the index must be previously fixed near its right position by the above-mentioned screw, before the adjusting screw is put in motion.

The nonius is a scale fixed to the end of the index, for the purpose, as before observed, of dividing the subdivisions on the arch into minutes; it sometimes contains a space of 7 degrees, or 21 subdivisions of the limb, and is divided into 20 equal parts; hence each division on the nonius will be one-twentieth part greater, that is, one minute longer, than the divisions on the arch; consequently, if the first division of the nonius, marked 0, be set precisely opposite to any degree, the relative position of the nonius and the arch must be altered one minute, before the next division on the nonius will coincide

with the next division on the arch, the second division will require a change of two minutes, the third of three minutes, and so on, till the 20th stroke on the nonius arrives at the next 20 minutes on the arch; the 0 on the nonius will then have moved exactly 20 minutes from the division whence it set out, and the intermediate divisions of each minute have been regularly pointed out by the divisions of the nonius.

The divisions of the nonius scale are in the above case reckoned from the middle towards the right, and from the left towards the middle; therefore the first 10 minutes are contained on the right of the 0, and the other 10 on the left. But this method of reckoning the divisions being found inconvenient, they are more generally counted beginning from the right-hand towards the left; and then 20 divisions on the nonius are equal to 19 on the limb, consequently one division on the arch will exceed one on the nonius by one-twentieth part, that is, one minute.

The 0 on the nonius points out the entire degrees and odd twenty minutes subtended by the objects observed; and if it coincides with a division on the arch, points out the required angle: thus, suppose the 0 on the nonius stands at 25 degrees, then 25 degrees will be the measure of the angles observed; if it coincides with the next division on the left-hand, 25 degrees 20 minutes is the angle; if with the second division beyond 25 degrees, then the angle will be 25 degrees 40 minutes; and so on in every instance where the 0 on the nonius coincides with a division on the arch; but if it does not coincide, then look for a division on the nonius that stands directly opposite to one on the arch, and that division on the nonius gives the odd minutes to be added to that on the arch nearest the right-hand of the 0 on the nonius; for example, suppose the index division does not coincide with 25 degrees, but that the next division to it on the nonius is the first coincident division, then is the required angle 25 degrees 1 minute; if it had been the second division the angle would have been 25 degrees 2 minutes, and so on to 20 minutes, when the 0 on the nonius would coincide with the first 20 minutes on the arch from 25 degrees. Again, let us suppose the 0 on the nonius to stand between 50 degrees and 50 degrees 20 minutes, and that the 15th division on the nonius coincides with a division on the arch, then is the angle 50 degrees 15 minutes. Further, let the 0 on the nonius stand between 45 degrees 20 minutes and 45 degrees 40 minutes, and at the same time the 14th division on the nonius stands directly opposite to a

division on the arch, then will the angle be 45 degrees 34 minutes.

The index glass *F* is a plane speculum, or mirror of glass quicksilvered, set in a brass frame, and so placed that the face of it is perpendicular to the plane of the instrument, and immediately over the centre of motion of the index. This mirror being fixed to the index moves along with it, and has its direction changed by the motion thereof.

This glass is designed to reflect the image of the sun, or any other object, upon either of the two horizon glasses, from whence it is reflected to the eye of the observer. The brass frame, with the glass, is fixed to the index by the screw *M*; the other screw *N* serves to place it in a perpendicular position, if by any accident it has been put out of order.

The horizon glasses *G* and *H* are two small speculums on the radius of the octant; the surface of the upper one is parallel to the index glass when the 0 on the nonius is at 0 on the arch; these mirrors receive the rays of the object reflected from the index glass, and transmit them to the observer. The fore horizon glass *G* is only silvered on its lower half, the upper half being transparent, in order that the direct object may be seen through it. The back horizon glass *H* is silvered at both ends; in the middle there is a transparent slit, through which the horizon may be seen. Each of these glasses is set in a brass frame, to which there is an axis; this axis passes through the wood-work, and is fitted to a lever on the under side of the quadrant, by which the glass may be turned a few degrees on its axis, in order to set it parallel to the index glass.

To set the glasses perpendicular to the plane of the quadrant there are two sunk screws, one before and one behind each glass: these screws pass through the plate on which the frame is fixed into another plate, so that by loosening one and tightening the other of these screws, the direction of the frame, with its mirror, may be altered, and thus be set perpendicular to the plane of the instrument.

The dark glasses, or shades, *I*, are used to prevent the bright rays of the sun, or the glare of the moon, from hurting the eye at the time of observation; there are generally three of them, two red, and one green. They are each set in a brass frame which turns on a centre, so that they may be used separately or together, as the brightness of the object may require. The green glass may be used also alone, if the sun be very faint; it is likewise used in taking observations of the moon; when these glasses are used for the fore observation, they are set

immediately before the fore horizon glass, as in fig. 1, but in front of the other horizon glass at *O* when a back observation is made.

The sight vanes *K* and *L* are pieces of brass, standing perpendicular to the plane of the instrument: the vane *K* is called the *fore sight vane*, and *L the back sight vane*. There are two holes in the fore sight vane, the lower of which and the upper edge of the silvered part of the fore horizon glass are equidistant from the plane of the instrument, and the other is opposite to the middle of the transparent part of that glass; the back sight vane has only one hole, which is exactly opposite to the middle of the transparent slit in the horizon glass to which it belongs: but as the back observations are liable to many inconveniences and errors, we shall not give any directions for their practice.

The adjusting lever (fig. 3), which is fixed on the back of the quadrant, serves to adjust the horizon glass, by placing it parallel to the index glass; when this lever is to be used, the screw *B* must be first loosened, and when by the adjuster *A*, the horizon glass is sufficiently moved, the screw *B* must be fastened again, by which means the horizon glass will be kept from changing its position.

ADJUSTMENTS.

The several parts of the quadrant being liable to be out of order from a variety of accidental circumstances, it is necessary to examine and adjust them, so that the instrument may be put into a proper state previous to taking observations.

An instrument properly adjusted must have the index glass and horizon glasses perpendicular to the plane of the quadrant; the plane of the fore horizon glass parallel, and that of the back horizon glass perpendicular, to the plane of the index glass, when the 0 on the nonius is at 0 on the arch; hence, the quadrant requires five adjustments, the first three of which, being once made, are not so liable as the last two to be out of order; however, they should all be occasionally examined, in case of an accident.

I. *To set the plane of the index glass perpendicular to that of the instrument.*

Place the index near to the middle of the arch, and holding the quadrant in a horizontal position, with the index glass close to the eye, look obliquely down the glass, in such a manner that you may see the arch of the quadrant by direct view and by reflection at the same time; if they join in one direct line,

and the arch seen by reflection forms an exact plane, or straight line, with the arch seen by direct view, or if the image of any point of the arch near *B* appear of the same height as the corresponding part of the arch near *C*, seen direct, the glass is perpendicular to the plane of the quadrant; if not, it must be restored to its right position by loosening the screw *M*, and tightening the screw *N*, or *vice versa*, by a contrary operation.

II. *To set the fore horizon glass parallel to the index glass, the index being at* 0.

Set the 0 on the nonius exactly against 0 on the arch, and fix it there by the screw at the under side. Then holding the quadrant vertically, with the arch lowermost, look through the sight vane, at the edge of the sea, or any other well-defined and distant object. Now, if the horizon in the silvered part exactly meets, and forms one continued line with that seen through the unsilvered part, the horizon glass is parallel to the index glass. But if the horizons do not coincide, then loosen the button-screw in the middle of the lever, on the under side of the quadrant, and move the horizon glass on its axis, by turning the nut at the end of the adjusting lever, till you have made them perfectly coincide; then fix the lever firmly in this situation by tightening the button-screw. This adjustment ought to be repeated before and after every observation. Some observers adopt the following method, which is called finding the *index error*. Let the horizon glass remain fixed, and move the index till the image and object coincide; then observe whether 0 on the nonius agrees with 0 on the arch, if it does not, the number of minutes by which they differ is to be added to the observed altitude or angle, if the 0 on the nonius be to the right of the 0 on the arch, but if to the left of the 0 on the limb, it is to be subtracted.

It has already been observed, that that part of the arch beyond 0 towards the right-hand is called the arch of excess: the nonius, when the 0 on it is at that part, must be read the contrary way, or, which is the same thing, you may read off the minutes in the usual way, and then their complement to 20 minutes will be the real number to be added to the degrees and minutes pointed out by the 0 on the nonius.

III. *To set the fore horizon glass perpendicular to the plane of the quadrant.*

Having previously made the above adjustment, incline the quadrant on one side as much as possible, provided the horizon continues to be seen in both parts of the glass; if, when the

instrument is thus inclined, the edge of the sea seen through the lower hole of the sight vane continues to form one unbroken line, the horizon glass is perfectly adjusted; but if the reflected horizon be separated from that seen by direct vision, the speculum is not perpendicular to the plane of the quadrant: then if the limb of the quadrant is inclined towards the horizon, with the face of the instrument upwards, and the reflected sea appears higher than the real sea, you must slacken the screw before the horizon glass, and tighten that which is behind it; but if the reflected sea appears lower, the contrary must be performed. Care must be always taken in this adjustment to loosen one screw before the other is screwed up, and to leave the adjusting screws tight, so as to draw with a moderate force against each other.

This adjustment may be also made by the sun, moon, or a star: in this case the quadrant is to be held in a vertical position; if the image seen by reflection appears to the right or left of the object seen directly, then the glass must be adjusted as before by the two screws.

It will be necessary, after having made this adjustment, to examine if the horizon glass still continues to be parallel to the index glass, as sometimes by turning the sunk screws the plane of the horizon glass will have its position altered.

USE OF HADLEY'S QUADRANT.

The use of the quadrant is to ascertain the angle subtended by two distant objects at the eye of the observer; but principally to observe the altitude of a celestial object above the horizon. This is pointed out by the index when one of the objects seen by reflection is made to coincide with the other, seen through the transparent part of the horizon glass.

To take an altitude of the sun, moon, or a star, by a fore observation.

Having previously adjusted the instrument, place the 0 on the nonius opposite to 0 on the arch, and turn down one or more of the screens, according to the brightness of the sun; then apply the eye to the upper hole in the fore sight vane, if the sun's image be very bright, otherwise to the lower, and holding the quadrant vertically, look directly towards the sun, so as to let it be behind the silvered part of the horizon glass, then the coloured sun's image will appear on the speculum, move the index forward till the sun's image, which will appear to descend, just touches the horizon with its lower or upper limb; if the upper hole be looked through, the sun's image must be made to appear in the middle of the trans arent part

of the horizon, but if it be the lower hole, hold the quadran so that the sun's image may be bisected by the line joining the silvered and transparent parts of the horizon glass.

The sun's limb ought to touch that part of the horizon immediately under the sun, but as this point cannot be exactly ascertained, it will be therefore necessary for the observer to give the quadrant a slow motion from side to side, turning at the same time upon his heel, by which motion the sun will appear to sweep the horizon, and must be made just to touch it at the lowest part of the arch; the degrees and minutes then pointed out by the index on the limb of the quadrant will be the observed altitude of that limb which is brought in contact with the horizon.

When the meridian or greatest altitude is required, the observation should be commenced a short time before the object comes to the meridian; being brought down to the horizon, it will appear for a few minutes to rise slowly; when it is again to be made to coincide with the horizon by moving the index forward; this must be repeated until the object begins to descend, when the index is to be secured, and the observation to be read off.

From this description of the quadrant and its use, the manner of adjusting and using the sextant will be readily apprehended. Our limits will not allow a particular description of this excellent instrument.

The Artificial Horizon.

In many cases it happens that altitudes are to be taken on land by the quadrant or sextant; which, for want of a natural horizon, can only be obtained by an artificial one. There has been a variety of these sorts of instruments made, but the kind now described is allowed to be the only one that can be depended upon. It consists of a wooden or metal-framed roof, containing two true parallel glasses of about 5 by 2½ inches, fixed not too tight in the frames of the roof. This serves to shelter from the air a wooden trough filled with quicksilver. In making an observation by it with the quadrant or sextant, the reflected image of the sun, moon, or other object is brought to coincide with the same object reflected from the glasses of the quadrant or sextant: half the angle shown upon the limb is the altitude above the horizon or level required. It is necessary in a set of observations that the roof be always placed the same way. When done with, the roof folds up flatwise, and, with the quicksilver in a bottle, &c. is packed into a portable flat case.

SECTION III.

VARIATION OF THE COMPASS.

The variation of the compass is the deviation of the points of the mariner's compass from the corresponding points of the horizon, and is termed east or west variation according as the magnetic needle or north point of the compass is inclined to the eastward or westward of the true north point of the horizon.

The true amplitude of any celestial object is an arch of the horizon contained between the true east or west points thereof and the centre of the object at the time of its rising or setting; or it is the degrees and minutes the object rises or sets to the northward or southward of the true east or west points of the horizon.

The magnetic amplitude is an arch contained between the east or west points of the compass and the centre of the object at rising or setting; or it is the bearing of the object by compass when in the horizon.

The true azimuth of an object is an arch of the horizon contained between the true meridian and the azimuth circle passing through the centre of the object.

The magnetic azimuth is an arch contained between the magnetic meridian and the azimuth circle passing through the centre of the object; or it is the bearing of the object by compass at any time when it is above the horizon.

The true amplitude or azimuth is found by calculation, and the magnetic amplitude or azimuth by an azimuth compass.

The magnetic amplitude or azimuth of the sun, or any celestial object, may be accurately observed by Mr. M'Culloch's patent compass, of which the following is a description.

DESCRIPTION OF THE AZIMUTH COMPASS.

Frontispiece, fig. 4, contains a perspective view of the azimuth compass ready for observation. The needle and card of this compass are similar to those of the steering compass, with this difference only, that a circular ring of silvered brass, divided into 360°, or rather four times 90°, circumscribes the card: *b* represents the compass-box, which is of brass, and has a hollow conical bottom; *e* is the prop or support of the compass-box, which stands in a brass socket screwed to the bottom of the wooden box, and may be turned round at pleasure; *h* is one of the guards, the other, being directly opposite, is hid by the box,—each guard has a slit, in which a pin projecting from the side of the box may move freely in a vertical direction; 1 is a brass bar, upon which, at right angles, the side-vanes are fixed,—a line is drawn along the middle of this bar, which line, the lines in the vanes, and the threads joining their tops are in

the same plane; 2 is a coloured glass moveable in the vane 3; 4 is a magnifying glass moveable in the other vane, whose focal distance is nearly equal to the distance between the vanes; 5 is the vernier, which contains six divisions, and as the limb of the card is divided into half-degrees, each division of the vernier is therefore five minutes,—the interior surface of the vernier is ground to a sphere, whose radius is equal to that of the card; 6 is a slide or stopper connected with the vernier, which serves to push the vernier close to the card, and thereby prevent it from vibrating as soon as the observation of the amplitude or azimuth is completed, and hence the degrees and parts of a degree may be read off at leisure with certainty; 7 is a convex glass, to assist the eye in reading off the observed amplitude or azimuth.

To observe the sun's amplitude.

Turn the compass-box until the vane containing the magnifying glass is directed towards the sun; and when the bright speck, or rays of the sun collected by the magnifying glass, falls upon the slit in the other vane, stop the card by means of the nonius, and read off the amplitude.

Without using the magnifying glass, the sight may be directed through the dark glass towards the sun; and in this case the card is to be stopped when the sun is bisected by the thread in the other vane.

The observation should be made when the sun's lower limb appears somewhat more than his semidiameter above the horizon, because his centre is really then in the horizon, although it is apparently elevated on account of the refraction of the atmosphere: this is particularly to be noticed in high latitudes.

To observe the sun's azimuth.

Raise the magnifying glass to the upper part of the vane, and move the box, as before directed, until the bright speck fall on the other vane or on the line in the horizontal bar; the card is then to be stopped, and the divisions being read off will be the sun's magnetic azimuth.

If the card vibrate considerably at the time of observation, it will be better to observe the extreme vibrations and take their mean as the magnetic azimuth. When the magnetic azimuth is observed, the altitude of the object must be taken in order to obtain the true azimuth.

It will conduce much to accuracy if several azimuths be observed, with the corresponding altitudes, and the mean of the whole taken for the observation.

To find the variation of the compass by an amplitude.

RULE.—1. To the log. secant of the latitude, rejecting the index, add the log. sine of the sun's declination, corrected for the time and place of observation; their sum will be the log. sine of the true amplitude, to be reckoned from the east in the

morning or the west in the afternoon, towards the north or south. according to the declination.

2. Then if the true and magnetic amplitudes be both north or both south their difference is the variation, but if one be north and the other south their sum is the variation; and to know whether it be easterly or westerly, suppose the observer looking towards that point of the compass representing the magnetic amplitude; then if the true amplitude be to the right-hand of the magnetic amplitude the variation is east, but if to the left-hand it is west.

EXAMPLE I.

July 3, 1812, in latitude 9° 36′ S. the sun was observed to rise E. 12° 42′ N.; required the variation of the compass.

Latitude		9° 36′ S.	- -	Secant	0.00613
Declination		22 59 N.	- -	Sine	9.59158
True amplitude	E.	23 20 N.	- -	Sine	9.59771
Mag. amplitude	E.	12 42 N.			
Variation		10 38 W.,			

Variation 10 38 W., because the true amplitude is to the left of the magnetic.

EXAMPLE II.

September 24, 1812, in latitude 26° 32′ N. and longitude 78° W. the sun's centre was observed to set W. 6° 15′ S. about 6h. P. M.; required the variation of the compass.

Sun's declination		0° 30′ S.			
Corr. for long. 78° W.		+ 5			
Corr. for time 6h. P. M.		+ 6			
Reduced declination		0 41	- - -	Sine	8.07650
Latitude		26 32	- - -	Secant	0.04834
True amplitude	W.	0 46 S.	- -	Sine	8.12484
Mag. amplitude	W.	6 15 S.			
Variation		5 29 E.,			

Variation 5 29 E., because the true amplitude is to the right-hand of the magnetic.

To find the variation of the compass by an azimuth.

RULE.—1. Reduce the sun's declination to the time and place of observation, and compute the true altitude of the sun's centre.

2. Subtract the sun's declination from 90° when the latitude and declination are of the same name, or add it to 90° when they are of contrary names, and the sum or remainder will be the sun's polar distance.

3. Add together the sun's polar distance, the latitude of the place, and the altitude of the sun; take the difference between half their sum and the polar distance, and note the remainder.

4. Then add together
the log. secant of the altitude } rejecting their indices,
the log. secant of the latitude }
the log. co-sine of the half-sum,
and the log. co-sine of the remainder.

5. Half the sum of these four logarithms will be the sine of an arch, which doubled will be the sun's true azimuth; to be reckoned from the south in north latitude, and from the north in south latitude; towards the east in the morning, and towards the west in the afternoon.

6. Then if the true and observed azimuths be both on the east or both on the west side of the meridian, their difference is the variation; but if one be on the east and the other on the west side of the meridian, their sum is the variation: and to know if it be east or west, suppose the observer looking towards that point of the compass representing the magnetic azimuth; then if the true azimuth be to the right of the magnetic, the variation is east, but if the true be to the left of the magnetic the variation is west.

EXAMPLE.

November 2, 1812, in latitude 25° 32′ N. and longitude 75° W. the altitude of the sun's lower limb was observed to be 15° 36′, about 4h. 10m. P. M., his magnetic azimuth at that time being S. 58° 32′ W., and the height of the eye 18 feet; required the variation of the compass.

Sun's dec. Nov. 2, at n.	14°	48′ S.	Obs. alt. sun's lower limb	15° 36′
Corr. for long. 75° W.	+	4	Semidiameter 16′ }	+ 12
Co. for ti. 4h. 10m. af. n.	+	3	Dip 4 }	
Reduced declination	14	55		15 48
	90	00	Refraction	3
Polar distance	104	55	True altitude	15 45
Altitude	15	45	- - Secant 0.01662	
Latitude	25	32	- - Secant 0.04463	
Sum	146	12		
Half	73	6	- - Co-sine 9.46345	
Remainder	31	49	- - Co-sine 9.92929	
			19.45399	
	32	14	- - Sine 9.72699	
		2		
True azimuth S.	64	28 W.		
Mag. azimuth S.	58	32 W.		
Variation	5	56 east, because the true azimuth is to the right of the magnetic.		

To draw a true meridian line to a map, having the variation and magnetical meridian given.

On any magnetical meridian or parallel, upon which the map is protracted, set off an angle from the north towards the east, equal to the degrees or quantity of variation if it be westerly, or from the north towards the west if it be easterly, and the line which constitutes such an angle with the magnetical meridian will be a true meridian line.

For if the variation be westerly, the magnetical meridian will be the quantity of variation of the west side of the true meridian, but if easterly, on the east side; therefore the true meridian must be a like quantity on the east side of the magnetical one when the variation is westerly, and on the west side when it is easterly.

To lay out a true meridian line by the circumferentor.

If the variation be westerly, turn the box about till the north of the needle points as many degrees from the flower-de-luce towards the east of the box, or till the south of the needle points the like number of degrees from the south towards the west, as are the number of degrees contained in the variation, and the index will be then due north and south; therefore, if a line be struck out in the direction thereof, it will be a true meridian line.

If the variation was easterly, let the north of the needle point as many degrees from the flower-de-luce towards the west of the box, or let the south of the needle point as many degrees towards the east, as are the number of degrees contained in the variation, and then the north and south of the box will coincide with the north and south points of the horizon, and consequently a line being laid out by the direction of the index will be a true meridian line.

This will be found to be very useful in setting a horizontal dial, for if you lay the edge of the index by the base of the stile of the dial, and keep the angular point of the stile towards the south of the box, and allow the variation as before, the dial will then be due north and south, and in its proper situation, provided the plane upon which it is fixed be duly horizontal, and the sun be south at noon; but in places where it is north at noon the angular point of the index must be turned to the north.

How maps may be traced by the help of a true meridian line.

If all maps had a true meridian line laid out upon them, it would be easy, by producing it, and drawing parallels, to make out field-notes; and by knowing the variation, and allowing it upon every bearing, and having the distances, you would have notes sufficient for a trace. But a true meridian line is seldom to be met with; therefore we are obliged to have recourse to the foregoing method. It is therefore advised to lay out a true meridian line upon every map.

To find the difference between the present variation, and that at a time when a tract was formerly surveyed, in order to trace or run out the original lines.

If the old variation be specified in the map or writings, and the present be known, by calculation or otherwise, then the difference is immediately seen by inspection; but as it more frequently happens that neither is certainly known, and as the variation of different instruments is not always alike at the same time, the following practical method will be found to answer every purpose.

Go to any part of the premises where any two adjacent corners are known; and if one can be seen from the other, take their bearing; which, compared with that of the same line in the former survey, shows the difference. But if trees, hills, &c. obstruct the view of the object, run the line according to the given bearing, and observe the nearest distance between the line so run and the corner, then,

As the length of the whole line
Is to 57.3 degrees,*
So is the said distance
To the difference of variation required.

EXAMPLE.

Suppose it be required to run a line which some years ago bore NE. 45°, distance 80 perches, and in running this line by the given bearing, the corner is found 20 links to the left-hand; what allowance must be made on each bearing to trace the old lines, and what is the present bearing of this particular line by the compass?

```
      P.           Deg.         L.
    As 80    :     57.3   : :   20
       25            20
    ------        ------
     2|000        1146.0(0° 34'
                      60
                  ---------
                  2)68|760.0
                  ---------
```

Answer, 34 minutes, or a little better than half a degree to the left-hand, is the allowance required, and the line in question bears N. 44° 26′ E.

Note.—The different variations do not affect the area in the calculation, as they are similar in every part of the survey.

* 57.3 is the radius of a circle (nearly) in such parts as the circumference contains 360.

THE END

A TABLE

OF

LOGARITHMS OF NUMBERS

FROM 1 TO 10,000.

N.	Log.	N.	Log.	N.	Log.	N.	Log.
1	0.000000	26	1.414973	51	1.707570	76	1.880814
2	0.301030	27	1.431364	52	1.716003	77	1.886491
3	0.477121	28	1.447158	53	1.724276	78	1.892095
4	0.602060	29	1.462398	54	1.732394	79	1.897627
5	0.698970	30	1.477121	55	1.740363	80	1.903090
6	0.778151	31	1.491362	56	1.748188	81	1.908485
7	0.845098	32	1.505150	57	1.755875	82	1.913814
8	0.903090	33	1.518514	58	1.763428	83	1.919078
9	0.954243	34	1.531479	59	1.770852	84	1.924279
10	1.000000	35	1.544068	60	1.778151	85	1.929419
11	1.041393	36	1.556303	61	1.785330	86	1.934498
12	1.079181	37	1.568202	62	1.792392	87	1.939519
13	1.113943	38	1.579784	63	1.799341	88	1.944483
14	1.146128	39	1.591065	64	1.806180	89	1.949390
15	1.176091	40	1.602060	65	1.812913	90	1.954243
16	1.204120	41	1.612784	66	1.819544	91	1.959041
17	1.230449	42	1.623249	67	1.826075	92	1.963788
18	1.255273	43	1.633468	68	1.832509	93	1.968483
19	1.278754	44	1.643453	69	1.838849	94	1.973128
20	1.301030	45	1.653213	70	1.845098	95	1.977724
21	1.322219	46	1.662758	71	1.851258	96	1.982271
22	1.342423	47	1.672098	72	1.857333	97	1.986772
23	1.361728	48	1.681241	73	1.863323	98	1.991226
24	1.380211	49	1.690196	74	1.869232	99	1.995635
25	1.397940	50	1.698970	75	1.875061	100	2.000000

N.B. In the following table, in the last nine columns of each page, where the first or leading figures change from 9's to 0's, points or dots are introduced instead of the 0's through the rest of the line, to catch the eye, and to indicate that from thence the annexed first two figures of the Logarithm in the second column stand in the next lower line.

N.	0	1	2	3	4	5	6	7	8	9	D.
100	000000	0434	0868	1301	1734	2166	2598	3029	3461	3891	432
101	4321	4751	5181	5609	6038	6466	6894	7321	7748	8174	428
102	8600	9026	9451	9876	.300	.724	1147	1570	1993	2415	424
103	012837	3259	3680	4100	4521	4940	5360	5779	6197	6616	419
104	7033	7451	7868	8284	8700	9116	9532	9947	.361	.775	416
105	021189	1603	2016	2428	2841	3252	3664	4075	4486	4896	412
106	5306	5715	6125	6533	6942	7350	7757	8164	8571	8978	408
107	9384	9789	.195	.600	1004	1408	1812	2216	2619	3021	404
108	033424	3826	4227	4628	5029	5430	5830	6230	6629	7028	400
109	7426	7825	8223	8620	9017	9414	9311	.207	.602	.998	396
110	041393	1787	2182	2576	2969	3362	3755	4148	4540	4932	393
111	5323	5714	6105	6495	6885	7275	7664	8053	8442	8830	389
112	9218	9606	9993	.380	.766	1153	1538	1924	2309	2694	386
113	053078	3463	3846	4230	4613	4996	5378	5760	6142	6524	382
114	6905	7286	7666	8046	8426	8805	9185	9563	9942	.320	379
115	060698	1075	1452	1829	2206	2582	2958	3333	3709	4083	376
116	4458	4832	5206	5580	5953	6326	6699	7071	7443	7815	372
117	8186	8557	8928	9298	9668	..38	.407	.776	1145	1514	369
118	071882	2250	2617	2985	3352	3718	4085	4451	4816	5182	366
119	5547	5912	6276	6640	7004	7368	7731	8094	8457	8819	363
120	079181	9543	9904	.266	.626	.987	1347	1707	2067	2426	360
121	082785	3144	3503	3861	4219	4576	4934	5291	5647	6004	357
122	6360	6716	7071	7426	7781	8136	8490	8845	9198	9552	355
123	9905	.258	.611	.963	1315	1667	2018	2370	2721	3071	351
124	093422	3772	4122	4471	4820	5169	5518	5866	6215	6562	349
125	6910	7257	7604	7951	8298	8644	8990	9335	9681	..26	346
126	100371	0715	1059	1403	1747	2091	2434	2777	3119	3462	343
127	3804	4146	4487	4828	5169	5510	5851	6191	6531	6871	340
128	7210	7549	7888	8227	8565	8903	9241	9579	9916	.253	338
129	110590	0926	1263	1599	1934	2270	2605	2940	3275	3609	335
130	113943	4277	4611	4944	5278	5611	5943	6276	6608	6940	333
131	7271	7603	7934	8265	8595	8926	9256	9586	9915	.245	330
132	120574	0903	1231	1560	1888	2216	2544	2871	3198	3525	328
133	3852	4178	4504	4830	5156	5181	5806	6131	6456	6781	325
134	7105	7429	7753	8076	8399	8722	9045	9368	9690	..12	323
135	130334	0655	0977	1298	1619	1939	2260	2580	2900	8219	321
136	3539	3858	4177	4496	4814	5133	5451	5769	6086	6403	318
137	6721	7037	7354	7671	7987	8303	8618	8934	9249	9564	315
138	9879	.194	.508	.822	1136	1450	1763	2076	2389	2702	314
139	143015	3327	3639	3951	4263	4574	4885	5196	5507	5818	311
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142	152288	2594	2900	3205	3510	3815	4120	4424	4728	5032	305
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147	7317	7613	7908	8203	8497	8792	9086	9380	9674	9968	295
148	170262	0555	0848	1141	1434	1726	2019	2311	2603	2895	293
149	3186	3478	3769	4060	4351	4641	4932	5222	5512	5802	291
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152	181844	2129	2415	2700	2985	3270	3555	3839	4123	4407	285
153	4691	4975	5259	5542	5825	6108	6391	6674	6956	7239	283
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155	190332	0612	0892	1171	1451	1730	2010	2289	2567	2846	279
156	3125	3403	3681	3959	4237	4514	4792	5069	5346	5623	278
157	5899	6176	6453	6729	7005	7281	7556	7832	8107	8382	276
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167	2716	2976	3236	3496	3755	4015	4274	4533	4792	5051	259
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184	4818	5054	5290	5525	5761	5996	6232	6467	6702	6937	235
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186	9513	9746	9980	.213	.446	.679	.912	1144	1377	1609	233
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191	281033	1261	1488	1715	1942	2169	2396	2622	2849	3075	227
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216	4454	4655	4856	5057	5257	5458	5658	5859	6059	6260	201
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222	6353	6549	6744	6939	7135	7330	7525	7720	7915	8110	195
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225	2183	2375	2568	2761	2954	3147	3339	3532	3724	3916	193
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227	6026	6217	6408	6599	6790	6981	7172	7363	7554	7744	191
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229	9835	..25	.215	.404	.593	.783	.972	1161	1350	1539	189
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233	7356	7542	7729	7915	8101	8287	8473	8659	8845	9030	186
234	9216	9401	9587	9772	9958	.143	.328	.513	.698	.883	185
235	371068	1253	1437	1622	1806	1991	2175	2360	2544	2728	184
236	2912	3096	3280	3464	3647	3831	4015	4198	4382	4565	184
237	4748	4932	5115	5298	5481	5664	5846	6029	6212	6394	183
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248	4452	4627	4802	4977	5152	5326	5501	5676	5850	6025	175
249	6199	6374	6548	6722	6896	7071	7245	7419	7592	7766	174
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254	4834	5005	5176	5346	55.7	5688	5858	6029	6199	6370	171
255	6540	6710	6881	7051	7221	7391	7561	7731	7901	8070	170
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257	9933	.102	.271	.440	.609	.777	.946	1114	1283	1451	169
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259	3300	3467	3635	3803	3970	4137	4305	4472	4639	4806	167
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261	6641	6807	6973	7139	7306	7472	7638	7804	7070	8135	166
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265	3246	3410	3574	3737	3901	4065	4228	4392	4555	4718	164
266	4882	5045	5208	5371	5534	5697	5860	6023	6186	6349	163
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274	7751	7909	8067	8226	8384	8542	8701	8859	9017	9175	158
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284	3318	3471	3624	3777	3930	4082	4235	4387	4540	4692	153
285	4845	4997	5150	5302	5454	5606	5758	5910	6062	6214	152
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288	9392	9543	9694	9845	9995	.146	.296	.447	.597	.748	151
289	460898	1048	1198	1348	1499	1649	1799	1948	2098	2248	150
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292	5383	5532	5680	5829	5977	6126	6274	6423	6571	6719	149
293	6868	7016	7164	7312	7460	7608	7756	7904	8052	8200	148
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295	9822	9969	.116	.263	.410	.557	.704	.851	.998	1145	147
296	471292	1438	1585	1732	1878	2025	2171	2318	2464	2610	146
297	2756	2903	3049	3195	3341	3487	3633	3779	3925	4071	146
298	4216	4362	4508	4653	4799	4944	5090	5235	5381	5526	146
299	5671	5816	5962	6107	6252	6397	6542	6687	6832	6976	145
300	477121	7266	7411	7555	7700	7844	7989	8133	8278	8422	145
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302	480007	0151	0294	0438	0582	0725	0869	1012	1156	1299	144
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305	4300	4442	4585	4727	4869	5011	5153	5295	5437	5579	142
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307	7138	7280	7421	7563	7704	7845	7986	8127	8269	8410	141
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309	9958	..99	.239	.380	.520	.661	.801	.941	1081	1222	140
310	491362	1502	1642	1782	1922	2062	2201	2341	2481	2621	140
311	2760	2900	3040	3179	3319	3458	3597	3737	3876	4015	139
312	4155	4294	4433	4572	4711	4850	4989	5128	5267	5406	139
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314	6930	7068	7206	7344	7483	7621	7759	7897	8035	8173	138
315	8311	8448	8586	8724	8862	8999	9137	9275	9412	9550	138
316	9687	9824	9962	..99	.236	.374	.511	.648	.785	.922	137
317	501059	1196	1333	1470	1607	1744	1880	2017	2154	2291	137
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319	3791	3927	4063	4199	4335	4471	4607	4743	4878	5014	136
320	505150	5286	5421	5557	5693	5828	5964	6099	6234	6370	136
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327	4548	4681	4813	4946	5079	5211	5344	5476	5609	5741	133
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354	9003	9126	9249	9371	9494	9616	9739	9861	9984	.106	123
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357	2668	2790	2911	3033	3155	3276	3398	3519	3640	3762	121
358	3883	4004	4126	4247	4368	4489	4610	4731	4852	4973	121
359	5094	5215	5336	5457	5578	5699	5820	5940	6061	6182	121
360	556303	6423	6544	6664	6785	6905	7026	7146	7267	7387	120
361	7507	7627	7748	7868	7988	8108	8228	8349	8469	8589	120
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365	2293	2412	2531	2650	2769	2887	3006	3125	3244	3362	119
366	3481	3600	3718	3837	3955	4074	4192	4311	4429	4548	119
367	4666	4784	4903	5021	5139	5257	5376	5494	5612	5730	118
368	5848	5966	6084	6202	6320	6437	6555	6673	6791	6909	118
369	7026	7144	7262	7379	7497	7614	7732	7849	7967	8084	118
370	568202	8319	8436	8554	8671	8788	8905	9023	9140	9257	117
371	9374	9491	9608	9725	9842	9959	..76	.193	.309	.426	117
372	570543	0660	0776	0893	1010	1126	1243	1359	1476	1592	117
373	1709	1825	1942	2058	2174	2291	2407	2523	2639	2755	116
374	2872	2988	3104	3220	3336	3452	3568	3684	3800	3915	116
375	4031	4147	4263	4379	4494	4610	4726	4841	4957	5072	116
376	5188	5303	5419	5534	5650	5765	5880	5996	6111	6226	115
377	6341	6457	6572	6687	6802	6917	7032	7147	7262	7377	115
378	7492	7607	7722	7836	7951	8066	8181	8295	8410	8525	115
379	8639	8754	8868	8983	9097	9212	9326	9441	9555	9669	114
380	579784	9898	..12	.126	.241	.355	.469	.583	.697	.811	114
381	580925	1039	1153	1267	1381	1495	1608	1722	1836	1950	114
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383	3199	3312	3426	3539	3652	3765	3879	3992	4105	4218	113
384	4331	4444	4557	4670	4783	4896	5009	5122	5235	5348	113
385	5461	5574	5686	5799	5912	6024	6137	6250	6362	6475	113
386	6587	6700	6812	6925	7037	7149	7262	7374	7486	7599	112
387	7711	7823	7935	8047	8160	8272	8384	8496	8608	8720	112
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389	9950	..61	.173	.284	.396	.507	.619	.730	.842	.953	112
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396	7695	7805	7914	8024	8134	8243	8353	8462	8572	8681	110
397	8791	8900	9009	9119	9228	9337	9446	9556	9665	9774	109
398	9883	9992	.101	.210	.319	.428	.537	.646	.755	.864	109
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410	612784	2890	2996	3102	3207	3313	3419	3525	3630	3736	106
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462	4642	4736	4830	4924	5018	5112	5206	5299	5393	5487	94
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470	672098	2190	2283	2375	2467	2560	2652	2744	2836	2929	92
471	3021	3113	3205	3297	3390	3482	3574	3666	3758	3850	92
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473	4861	4953	5045	5137	5228	5320	5412	5503	5595	5687	92
474	5778	5870	5962	6053	6145	6236	6328	6419	6511	6602	92
475	6694	6785	6876	6968	7059	7151	7242	7333	7424	7516	91
476	7607	7698	7789	7881	7972	8063	8154	8245	8336	8427	91
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479	680336	0426	0517	0607	0698	0789	0879	0970	1060	1151	91
480	681241	1332	1422	1513	1603	1693	1784	1874	1964	2055	90
481	2145	2235	2326	2416	2506	2596	2686	2777	2867	2957	90
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485	5742	5831	5921	6010	6100	6189	6279	6368	6458	6547	89
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487	7529	7618	7707	7796	7886	7975	8064	8153	8242	8331	89
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490	690196	0285	0373	0462	0550	0639	0728	0816	0905	0993	89
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492	1965	2053	2142	2230	2318	2406	2494	2583	2671	2759	88
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494	3727	3815	3903	3991	4078	4166	4254	4342	4430	4517	88
495	4605	4693	4781	4868	4956	5044	5131	5219	5307	5394	88
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504	2431	2517	2603	2689	2775	2861	2947	3033	3119	3205	86
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507	5008	5094	5179	5265	5350	5436	5522	5607	5693	5778	86
508	5864	5949	6035	6120	6206	6291	6376	6462	6547	6632	85
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522	7671	7754	7837	7920	8003	8086	8169	8253	8336	8419	83
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525	720159	0242	0325	0407	0490	0573	0655	0738	0821	0903	83
526	0986	1068	1151	1233	1316	1398	1481	1563	1646	1728	82
527	1811	1893	1975	2058	2140	2222	2305	2387	2469	2552	82
528	2634	2716	2798	2881	2963	3045	3127	3209	3291	3374	82
529	3456	3538	3620	3702	3784	3866	3948	4030	4112	4194	82
530	724276	4358	4440	4522	4604	4685	4767	4849	4931	5013	82
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533	6727	6809	6890	6972	7053	7134	7216	7297	7379	7460	81
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535	8354	8435	8516	8597	8678	8759	8841	8922	9003	9084	81
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540	732394	2474	2555	2635	2715	2796	2876	2956	3037	3117	80
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545	6397	6476	6556	6635	6715	6795	6874	6954	7034	7113	80
546	7193	7272	7352	7431	7511	7590	7670	7749	7829	7908	79
547	7987	8067	8146	8225	8305	8384	8463	8543	8622	8701	79
548	8781	8860	8939	9018	9097	9177	9256	9335	9414	9493	79
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550	740363	0442	0521	0600	0678	0757	0836	0915	0994	1073	79
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552	1939	2018	2096	2175	2254	2332	2411	2489	2568	2646	79
553	2725	2804	2882	2961	3039	3118	3196	3275	3353	3431	78
554	3510	3588	3667	3745	3823	3902	3980	4058	4136	4215	78
555	4293	4371	4449	4528	4606	4684	4762	4840	4919	4997	78
556	5075	5153	5231	5309	5387	5465	5543	5621	5699	5777	78
557	5855	5933	6011	6089	6167	6245	6323	6401	6479	6556	78
558	6634	6712	6790	6868	6945	7023	7101	7179	7256	7334	78
559	7412	7489	7567	7645	7722	7800	7878	7955	8033	8110	78
560	748188	8266	8343	8421	8498	8576	8653	8731	8808	8885	77
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563	750508	0586	0663	0740	0817	0894	0971	1048	1125	1202	77
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565	2048	2125	2202	2279	2356	2433	2509	2586	2663	2740	77
566	2816	2893	2970	3047	3123	3200	3277	3353	3430	3506	77
567	3583	3660	3736	3813	3889	3966	4042	4119	4195	4272	77
568	4348	4425	4501	4578	4654	4730	4807	4883	4960	5036	76
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570	755875	5951	6027	6103	6180	6256	6332	6408	6484	6560	76
571	6636	6712	6788	6864	6940	7016	7092	7168	7244	7320	76
572	7396	7472	7548	7624	7700	7775	7851	7927	8003	8079	76
573	8155	8230	8306	8382	8458	8533	8609	8685	8761	8836	76
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575	9668	9743	9819	9894	9970	..45	.121	.196	.272	.347	75
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591	1587	1661	1734	1808	1881	1955	2028	2102	2175	2248	73
592	2322	2395	2468	2542	2615	2688	2762	2835	2908	2981	73
593	3055	3128	3201	3274	3348	3421	3494	3567	3640	3713	73
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606	2473	2544	2616	2688	2759	2831	2902	2974	3046	3117	72
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627	7268	7337	7406	7475	7545	7614	7683	7752	7821	7890	69
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637	4139	4208	4276	4344	4412	4480	4548	4616	4685	4753	68
638	4821	4889	4957	5025	5093	5161	5229	5297	5365	5433	68
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703	6955	7017	7079	7141	7202	7264	7326	7388	7449	7511	62
704	7573	7634	7696	7758	7819	7881	7943	8004	8066	8128	62
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771	7054	7111	7167	7223	7280	7336	7392	7449	7505	7561	56
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779	1537	1593	1649	1705	1760	1816	1872	1928	1983	2039	56
780	892095	2150	2206	2262	2317	2373	2429	2484	2540	2595	56
781	2651	2707	2762	2818	2873	2929	2985	3040	3096	3151	56
782	3207	3262	3318	3373	3429	3484	3540	3595	3651	3706	56
783	3762	3817	3873	3928	3984	4039	4094	4150	4205	4261	55
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797	1458	1513	1567	1622	1676	1731	1785	1840	1894	1948	54
798	2003	2057	2112	2166	2221	2275	2329	2384	2438	2492	54
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814	0624	0678	0731	0784	0838	0891	0944	0998	1051	1104	53
815	1158	1211	1264	1317	1371	1424	1477	1530	1584	1637	53
816	1690	1743	1797	1850	1903	1956	2009	2063	2116	2169	53
817	2222	2275	2328	2381	2435	2488	2541	2594	2647	2700	53
818	2753	2806	2859	2913	2966	3019	3072	3125	3178	3231	53
819	3284	3337	3390	3443	3496	3549	3602	3655	3708	3761	53
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821	4343	4396	4449	4502	4555	4608	4660	4713	4766	4819	53
822	4872	4925	4977	5030	5083	5136	5189	5241	5294	5347	53
823	5400	5453	5505	5558	5611	5664	5716	5769	5822	5875	53
824	5927	5980	6033	6085	6138	6191	6243	6296	6349	6401	53
825	6454	6507	6559	6612	6664	6717	6770	6822	6875	6927	53
826	6980	7033	7085	7138	7190	7243	7295	7348	7400	7453	53
827	7506	7558	7611	7663	7716	7768	7820	7873	7925	7978	52
828	8030	8083	8135	8188	8240	8293	8345	8397	8450	8502	52
829	8555	8607	8659	8712	8764	8816	8869	8921	8973	9026	52
830	919078	9130	9183	9235	9287	9340	9392	9444	9496	9549	52
831	9601	9653	9706	9758	9810	9862	9914	9967	..19	..71	52
832	920123	0176	0228	0280	0332	0384	0436	0489	0541	0593	52
833	0645	0697	0749	0801	0853	0906	0958	1010	1062	1114	52
834	1166	1218	1270	1322	1374	1426	1478	1530	1582	1634	52
835	1686	1738	1790	1842	1894	1946	1998	2050	2102	2154	52
836	2206	2258	2310	2362	2414	2466	2518	2570	2622	2674	52
837	2725	2777	2829	2881	2933	2985	3037	3089	3140	3192	52
838	3244	3296	3348	3399	3451	3503	3555	3607	3658	3710	52
839	3762	3814	3865	3917	3969	4021	4072	4124	4176	4228	52
840	924279	4331	4383	4434	4486	4538	4589	4641	4693	4744	52
841	4796	4848	4899	4951	5003	5054	5106	5157	5209	5261	52
842	5312	5364	5415	5467	5518	5570	5621	5673	5726	5776	52
843	5828	5879	5931	5982	6034	6085	6137	6188	6240	6291	51
844	6342	6394	6445	6497	6548	6600	6651	6702	6754	6805	51
845	6857	6908	6959	7011	7062	7114	7165	7216	7268	7319	51
846	7370	7422	7473	7524	7576	7627	7678	7730	7781	7832	51
847	7883	7935	7986	8037	8088	8140	8191	8242	8293	8345	51
848	8396	8447	8498	8549	8601	8652	8703	8754	8805	8857	51
849	8908	8959	9010	9061	9112	9163	9215	9266	9317	9368	51
850	929419	9470	9521	9572	9623	9674	9725	9776	9827	9879	51
851	9930	9981	..32	..83	.134	.185	.236	.287	.338	.389	51
852	930440	0491	0542	0592	0643	0694	0745	0796	0847	0898	51
853	0949	1000	1051	1102	1153	1204	1254	1305	1356	1407	51
854	1458	1509	1560	1610	1661	1712	1763	1814	1865	1915	51
855	1966	2017	2068	2118	2169	2220	2271	2322	2372	2423	51
856	2474	2524	2575	2626	2677	2727	2778	2829	2879	2930	51
857	2981	3031	3082	3133	3183	3234	3285	3335	3386	3437	51
858	3487	3538	3589	3639	3690	3740	3791	3841	3892	3943	51
859	3993	4044	4094	4145	4195	4246	4296	4347	4397	4448	51
860	934498	4549	4599	4650	4700	4751	4801	4852	4902	4953	50
861	5003	5054	5104	5154	5205	5255	5306	5356	5406	5457	50
862	5507	5558	5608	5658	5709	5759	5809	5860	5910	5960	50
863	6011	6061	6111	6162	6212	6262	6313	6363	6413	6463	50
864	6514	6564	6614	6665	6715	6765	6815	6865	6916	6966	50
865	7016	7066	7117	7167	7217	7267	7317	7367	7418	7468	50
866	7518	7568	7618	7668	7718	7769	7819	7869	7919	7969	50
867	8019	8069	8119	8169	8219	8269	8320	8370	8420	8470	50
868	8520	8570	8620	8670	8720	8770	8820	8870	8920	8970	50
869	9020	9070	9120	9170	9220	9270	9320	9369	9419	9469	50
870	939519	9569	9619	9669	9719	9769	9819	9869	9918	9968	50
871	940018	0068	0118	0168	0218	0267	0317	0367	0417	0467	50
872	0516	0566	0616	0666	0716	0765	0815	0865	0915	0964	50
873	1014	1064	1114	1163	1213	1263	1313	1362	1412	1462	50
874	1511	1561	1611	1660	1710	1760	1809	1859	1909	1958	50
875	2008	2058	2107	2157	2207	2256	2306	2355	2405	2455	50
876	2504	2554	2603	2653	2702	2752	2801	2851	2901	2950	50
877	3000	3049	3099	3148	3198	3247	3297	3346	3396	3445	49
878	3495	3544	3593	3643	3692	3742	3791	3841	3890	3939	49
879	3989	4038	4088	4137	4186	4236	4285	4335	4384	4433	49
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880	944483	4532	4581	4631	4680	4729	4779	4828	4877	4927	49
881	4976	5025	5074	5124	5173	5222	5272	5321	5370	5419	49
882	5469	5518	5567	5616	5665	5715	5764	5813	5862	5912	49
883	5961	6010	6059	6108	6157	6207	6256	6305	6354	6403	49
884	6452	6501	6551	6600	6649	6698	6747	6796	6845	6894	49
885	6943	6992	7041	7090	7140	7189	7238	7287	7336	7385	49
886	7434	7483	7532	7581	7630	7679	7728	7777	7826	7875	49
887	7924	7973	8022	8070	8119	8168	8217	8266	8315	8364	49
888	8413	8462	8511	8560	8609	8657	8706	8755	8804	8853	49
889	8902	8951	8999	9048	9097	9146	9195	9244	9292	9341	49
890	949390	9439	9488	9536	9585	9634	9683	9731	9780	9829	49
891	9878	9926	9975	..24	..73	.121	.170	.219	.267	.316	49
892	950365	0414	0462	0511	0560	0608	0657	0706	0754	0803	49
893	0851	0900	0949	0997	1046	1095	1143	1192	1240	1289	49
894	1338	1386	1435	1483	1532	1580	1629	1677	1726	1775	49
895	1823	1872	1920	1969	2017	2066	2114	2163	2211	2260	48
896	2308	2356	2405	2453	2502	2550	2599	2647	2696	2744	48
897	2792	2841	2889	2938	2986	3034	3083	3131	3180	3228	48
898	3276	3325	3373	3421	3470	3518	3566	3615	3663	3711	48
899	3760	3808	3856	3905	3953	4001	4049	4098	4146	4194	48
900	954243	4291	4339	4387	4435	4484	4532	4580	4628	4677	48
901	4725	4773	4821	4869	4918	4966	5014	5062	5110	5158	48
902	5207	5255	5303	5351	5399	5447	5495	5543	5592	5640	48
903	5688	5736	5784	5832	5880	5928	5976	6024	6072	6120	48
904	6168	6216	6265	6313	6361	6409	6457	6505	6553	6601	48
905	6649	6697	6745	6793	6840	6888	6936	6984	7032	7080	48
906	7128	7176	7224	7272	7320	7368	7416	7464	7512	7559	48
907	7607	7655	7703	7751	7799	7847	7894	7942	7990	8038	48
908	8086	8134	8181	8229	8277	8325	8373	8421	8468	8516	48
909	8564	8612	8659	8707	8755	8803	8850	8898	8946	8994	48
910	959041	9089	9137	9185	9232	9280	9328	9375	9423	9471	48
911	9518	9566	9614	9661	9709	9757	9804	9852	9900	9947	48
912	9995	..42	..90	.138	.185	.233	.280	.328	.376	.423	48
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914	0946	0994	1041	1089	1136	1184	1231	1279	1326	1374	47
915	1421	1469	1516	1563	1611	1658	1706	1753	1801	1848	47
916	1895	1943	1990	2038	2085	2132	2180	2227	2275	2322	47
917	2369	2417	2464	2511	2559	2606	2653	2701	2748	2795	47
918	2843	2890	2937	2985	3032	3079	3126	3174	3221	3268	47
919	3316	3363	3410	3457	3504	3552	3599	3646	3693	3741	47
920	963788	3835	3882	3929	3977	4024	4071	4118	4165	4212	47
921	4260	4307	4354	4401	4448	4495	4542	4590	4637	4684	47
922	4731	4778	4825	4872	4919	4966	5013	5061	5108	5155	47
923	5202	5249	5296	5343	5390	5437	5484	5531	5578	5625	47
924	5672	5719	5766	5813	5860	5907	5954	6001	6048	6095	47
925	6142	6189	6236	6283	6329	6376	6423	6470	6517	6564	47
926	6611	6658	6705	6752	6799	6845	6892	6939	6986	7033	47
927	7080	7127	7173	7220	7267	7314	7361	7408	7454	7501	47
928	7548	7595	7642	7688	7735	7782	7829	7875	7922	7969	47
929	8016	8062	8109	8156	8203	8249	8296	8343	8390	8436	47
930	968483	8530	8576	8623	8670	8716	8763	8810	8856	8903	47
931	8950	8996	9043	9090	9136	9183	9229	9276	9323	9369	47
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933	9882	9928	9975	..21	..68	.114	.161	.207	.254	.300	47
934	970347	0393	0440	0486	0533	0579	0626	0672	0719	0765	46
935	0812	0858	0904	0951	0997	1044	1090	1137	1183	1229	46
936	1276	1322	1369	1415	1461	1508	1554	1601	1647	1693	46
937	1740	1786	1832	1879	1925	1971	2018	2064	2110	2157	46
938	2203	2249	2295	2342	2388	2434	2481	2527	2573	2619	46
939	2666	2712	2758	2804	2851	2897	2943	2989	3035	3082	46
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941	3590	3636	3682	3728	3774	3820	3866	3913	3959	4005	46
942	4051	4097	4143	4189	4235	4281	4327	4374	4420	4466	46
943	4512	4558	4604	4650	4696	4742	4788	4834	4880	4926	46
944	4972	5018	5064	5110	5156	5202	5248	5294	5340	5386	46
945	5432	5478	5524	5570	5616	5662	5707	5753	5799	5845	46
946	5891	5937	5983	6029	6075	6121	6167	6212	6258	6304	46
947	6350	6396	6442	6488	6533	6579	6625	6671	6717	6763	46
948	6808	6854	6900	6946	6992	7037	7083	7129	7175	7220	46
949	7266	7312	7358	7403	7449	7495	7541	7586	7632	7678	46
950	977724	7769	7815	7861	7906	7952	7998	8043	8089	8135	46
951	8181	8226	8272	8317	8363	8409	8454	8500	8546	8591	46
952	8637	8683	8728	8774	8819	8865	8911	8956	9002	9047	46
953	9093	9138	9184	9230	9275	9321	9366	9412	9457	9503	46
954	9548	9594	9639	9685	9730	9776	9821	9867	9912	9958	46
955	980003	0049	0094	0140	0185	0231	0276	0322	0367	0412	45
956	0458	0503	0549	0594	0640	0685	0730	0776	0821	0867	45
957	0912	0957	1003	1048	1093	1139	1184	1229	1275	1320	45
958	1366	1411	1456	1501	1547	1592	1637	1683	1728	1773	45
959	1819	1864	1909	1954	2000	2045	2090	2135	2181	2226	45
960	982271	2316	2362	2407	2452	2497	2543	2588	2633	2678	45
961	2723	2769	2814	2859	2904	2949	2994	3040	3085	3130	45
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963	3626	3671	3716	3762	3807	3852	3897	3942	3987	4032	45
964	4077	4122	4167	4212	4257	4302	4347	4392	4437	4482	45
965	4527	4572	4617	4662	4707	4752	4797	4842	4887	4932	45
966	4977	5022	5067	5112	5157	5202	5247	5292	5337	5382	45
967	5426	5471	5516	5561	5606	5651	5696	5741	5786	5830	45
968	5875	5920	5965	6010	6055	6100	6144	6189	6234	6279	45
969	6324	6369	6413	6458	6503	6548	6593	6637	6682	6727	45
970	986772	6817	6861	6906	6951	6996	7040	7085	7130	7175	45
971	7219	7264	7309	7353	7398	7443	7488	7532	7577	7622	45
972	7666	7711	7756	7800	7845	7890	7934	7979	8024	8068	45
973	8113	8157	8202	8247	8291	8336	8381	8425	8470	8514	45
974	8559	8604	8648	8693	8737	8782	8826	8871	8916	8960	45
975	9005	9049	9094	9138	9183	9227	9272	9316	9361	9405	45
976	9450	9494	9539	9583	9628	9672	9717	9761	9806	9850	44
977	9895	9939	9983	..28	..72	.117	.161	.206	.250	.294	44
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979	0783	0827	0871	0916	0960	1004	1049	1093	1137	1182	44
980	991226	1270	1315	1359	1403	1448	1492	1536	1580	1625	44
981	1669	1713	1758	1802	1846	1890	1935	1979	2023	2067	44
982	2111	2156	2200	2244	2288	2333	2377	2421	2465	2509	44
983	2554	2598	2642	2686	2730	2774	2819	2863	2907	2951	44
984	2995	3039	3083	3127	3172	3216	3260	3304	3348	3392	44
985	3436	3480	3524	3568	3613	3657	3701	3745	3789	3833	44
986	3877	3921	3965	4009	4053	4097	4141	4185	4229	4273	44
987	4317	4361	4405	4449	4493	4537	4581	4625	4669	4713	44
988	4757	4801	4845	4889	4933	4977	5021	5065	5108	5152	44
989	5196	5240	5284	5328	5372	5416	5460	5504	5547	5591	44
990	995635	5679	5723	5767	5811	5854	5898	5942	5986	6030	44
991	6074	6117	6161	6205	6249	6293	6337	6380	6424	6468	44
992	6512	6555	6599	6643	6687	6731	6774	6818	6862	6906	44
993	6949	6993	7037	7080	7124	7168	7212	7255	7299	7343	44
994	7386	7430	7474	7517	7561	7605	7648	7692	7736	7779	44
995	7823	7867	7910	7954	7998	8041	8085	8129	8172	8216	44
996	8259	8303	8347	8390	8434	8477	8521	8564	8608	8652	44
997	8695	8739	8782	8826	8869	8913	8956	9000	9043	9087	44
998	9131	9174	9218	9261	9305	9348	9392	9435	9479	9522	44
999	9565	9609	9652	9696	9739	9783	9826	9870	9913	9957	43
N.	0	1	2	3	4	5	6	7	8	9	D.

A TABLE

OF

LOGARITHMIC

SINES AND TANGENTS,

FOR EVERY

DEGREE AND MINUTE

OF THE QUADRANT.

N.B The minutes in the left-hand column of each page, increasing downwards, belong to the degrees at the top; and those increasing upwards, in the right-hand column, belong to the degrees below.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
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1	6.463726	501717	000000	00	6.463726	501717	13.536274	59
2	764756	293485	000000	00	764756	293483	235244	58
3	940847	208231	000000	00	940847	208231	059153	57
4	7.065786	161517	000000	00	7.065786	161517	12.934214	56
5	162696	131968	000000	00	162696	131969	837304	55
6	241877	111575	9.999999	01	241878	111578	758122	54
7	308824	96653	999999	01	308825	99653	691175	53
8	366816	85254	999999	01	366817	85254	633183	52
9	417968	76263	999999	01	417970	76263	582030	51
10	463725	68988	999998	01	463727	68988	536273	50
11	7.505118	62981	9.999998	01	7.505120	62981	12.494880	49
12	542906	57936	999997	01	542909	57933	457091	48
13	577668	53641	999997	01	577672	53642	422328	47
14	609853	49938	999996	01	609857	49939	390143	46
15	639816	46714	999996	01	639820	46715	360180	45
16	667845	43881	999995	01	667849	43882	332151	44
17	694173	41372	999995	01	694179	41373	305821	43
18	718997	39135	999994	01	719003	39136	280997	42
19	742477	37127	999993	01	742484	37128	257516	41
20	764754	35315	999993	01	764761	35136	235239	40
21	7.785943	33672	9.999992	01	7.785951	33673	12.214049	39
22	806146	32175	999991	01	806155	32176	193845	38
23	825451	30805	999990	01	825460	30806	174540	37
24	843934	29547	999989	02	843944	29549	156056	36
25	861662	28338	999988	02	861674	28390	138326	35
26	878695	27317	999988	02	878708	27318	121292	34
27	895085	26323	999987	02	895099	26325	104901	33
28	910879	25399	999986	02	910894	25401	089106	32
29	926119	24538	999985	02	926134	24540	073866	31
30	940842	23733	999983	02	940858	23735	059142	30
31	7.955082	22980	9.999982	02	7.955100	22981	12.044900	29
32	968870	22273	999981	02	968889	22275	031111	28
33	982233	21608	999980	02	982253	21610	017747	27
34	995198	20981	999979	02	995219	20983	004781	26
35	8.007787	20390	999977	02	8.007809	20392	11.992191	25
36	020021	19831	999976	02	020045	19833	979955	24
37	031919	19302	999975	02	031945	19305	968055	23
38	043501	18801	999973	02	043527	18803	956473	22
39	054781	18325	999972	02	054809	18327	945191	21
40	065776	17872	999971	02	065806	17874	934194	20
41	8.076500	17441	9.999969	02	8.076531	17444	11.923469	19
42	086965	17031	999968	02	086997	17034	913003	18
43	097183	16639	999966	02	097217	16642	902783	17
44	107167	16265	999964	03	107202	16268	892797	16
45	116926	15908	999963	03	116963	15910	883037	15
46	126471	15566	999961	03	126510	15568	873490	14
47	135810	15238	999959	03	135851	15241	864149	13
48	144953	14924	999958	03	144996	14927	855004	12
49	153907	14622	999956	03	153952	14627	846048	11
50	162681	14333	999954	03	162727	14336	837273	10
51	8.171280	14054	9.999952	03	8.171328	14057	11 828672	9
52	179713	13786	999950	03	179763	13790	820237	8
53	187985	13529	999948	03	188036	13532	811964	7
54	196102	13280	999946	03	196156	13284	803844	6
55	204070	13041	999944	03	204126	13044	795874	5
56	211895	12810	999942	04	211953	12814	788047	4
57	219581	12587	999940	04	219641	12590	780359	3
58	227134	12372	999938	04	227195	12376	772805	2
59	234557	12164	999936	04	234621	12168	765379	1
60	241855	11963	999934	04	241921	11967	758079	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D	Cotang.	
0	8.241855	11963	9.999934	04	8.241921	11967	11.758079	60
1	249033	11768	999932	04	249102	11772	750898	59
2	256094	11580	999929	04	256165	11584	743835	58
3	263042	11398	999927	04	263115	11402	736885	57
4	269881	11221	999925	04	269956	11225	730044	56
5	276614	11050	999922	04	276691	11054	723309	55
6	283243	10883	999920	04	283323	10887	716677	54
7	289773	10721	999918	04	289856	10726	710144	53
8	296207	10565	999915	04	296292	10570	703708	52
9	302546	10413	999913	04	302634	10418	697366	51
10	308794	10266	999910	04	308884	10270	691116	50
11	8.314954	10122	9.999907	04	8.315046	10126	11.684954	49
12	321027	9982	999905	04	321122	9987	678878	48
13	327016	9847	999902	04	327114	9851	672886	47
14	332924	9714	999899	05	333025	9719	666975	46
15	338753	9586	999897	05	338856	9590	661144	45
16	344504	9460	999894	05	344610	9465	655390	44
17	350181	9338	999891	05	350289	9343	649711	43
18	355783	9219	999888	05	355895	9224	644105	42
19	361315	9103	999885	05	361430	9108	638570	41
20	366777	8990	999882	05	366895	8995	633105	40
21	8.372171	8880	9.999879	05	8.372292	8885	11.627708	39
22	377499	8772	999876	05	377622	8777	622378	38
23	382762	8667	999873	05	382889	8672	617111	37
24	387962	8564	999870	05	388092	8570	611908	36
25	393101	8464	999867	05	393234	8470	606766	35
26	398179	8366	999864	05	398315	8371	601685	34
27	403199	8271	999861	05	403338	8276	596662	33
28	408161	8177	999858	05	408304	8182	591696	32
29	413068	8086	999854	05	413213	8091	586787	31
30	417919	7996	999851	06	418068	8002	581932	30
31	8.422717	7909	9.999848	06	8.422869	7914	11.577131	29
32	427462	7823	999844	06	427618	7830	572382	28
33	432156	7740	999841	06	432315	7745	567685	27
34	436800	7657	999838	06	436962	7663	563038	26
35	441394	7577	999834	06	441560	7583	558440	25
36	445941	7499	999831	06	446110	7505	553890	24
37	450440	7422	999827	06	450613	7428	549387	23
38	454893	7346	999823	06	455070	7352	544930	22
39	459301	7273	999820	06	459481	7279	540519	21
40	463665	7200	999816	06	463849	7206	536151	20
41	8.467985	7129	9.999812	06	8.468172	7135	11.531828	19
42	472263	7060	999809	06	472454	7066	527546	18
43	476498	6991	999805	06	476693	6998	523307	17
44	480693	6924	999801	06	480892	6931	519108	16
45	484848	6859	999797	07	485050	6865	514950	15
46	488963	6794	999793	07	489170	6801	510830	14
47	493040	6731	999790	07	493250	6738	506750	13
48	497078	6669	999786	07	497293	6676	502707	12
49	501080	6608	999782	07	501298	6615	498702	11
50	505045	6548	999778	07	505267	6555	494733	10
51	8.508974	6489	9.999774	07	8.509200	6496	11.490800	9
52	512867	6431	999769	07	513098	6439	486902	8
53	516726	6375	999765	07	516961	6382	483039	7
54	520551	6319	999761	07	520790	6326	479210	6
55	524343	6264	999757	07	524586	6272	475414	5
56	528102	6211	999753	07	528349	6218	471651	4
57	531828	6158	999748	07	532080	6165	467920	3
58	535523	6106	999744	07	535779	6113	464221	2
59	539186	6055	999740	07	539447	6062	460553	1
60	542819	6004	999735	07	543084	6012	456916	0
	Cosine		Sine		Cotang.		Tang	M.

88 Degrees

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8.542819	6004	9.999735	07	8.543084	6012	11.456916	60
1	546422	5955	999731	07	546691	5962	453309	59
2	549995	5906	999726	07	550268	5914	449732	58
3	553539	5858	999722	08	553817	5866	446183	57
4	557054	5811	999717	08	557336	5819	442664	56
5	560540	5765	999713	08	560828	5773	439172	55
6	563999	5719	999708	08	564291	5727	435709	54
7	567431	5674	999704	08	567727	5682	432273	53
8	570836	5630	999699	08	571137	5638	428863	52
9	574214	5587	999694	08	574520	5595	425480	51
10	577566	5544	999689	08	577877	5552	422123	50
11	8.580892	5502	9.999685	08	8.581208	5510	11.418792	49
12	584193	5460	999680	08	584514	5468	415486	48
13	587469	5419	999675	08	587795	5427	412205	47
14	590721	5379	999670	08	591051	5387	408949	46
15	593948	5339	999665	08	594283	5347	405717	45
16	597152	5300	999660	08	597492	5308	402508	44
17	600332	5261	999655	08	600677	5270	399323	43
18	603489	5223	999650	08	603839	5232	396161	42
19	606623	5186	999645	09	606978	5194	393022	41
20	609734	5149	999640	09	610094	5158	389906	40
21	8.612823	5112	9.999635	09	8.613189	5121	11.386811	39
22	615891	5076	999629	09	616262	5085	383738	38
23	618937	5041	999624	09	619313	5050	380687	37
24	621962	5006	999619	09	622343	5015	377657	36
25	624965	4972	999614	09	625352	4981	374648	35
26	627948	4938	999608	09	628340	4947	371660	34
27	6[illegible]911	4904	999603	09	631308	4913	368692	33
28	633854	4871	999597	09	634256	4880	365744	32
29	636776	4839	999592	09	637184	4848	362816	31
30	639680	4806	999586	09	640093	4816	359907	30
31	8.642563	4775	9.999581	09	8.642982	4784	11.357018	29
32	645428	4743	999575	09	645853	4753	354147	28
33	648274	4712	999570	09	648704	4722	351296	27
34	651102	4682	999564	09	651537	4691	348463	26
35	653911	4652	999558	10	654352	4661	345648	25
36	656702	4622	999553	10	657149	4631	342851	24
37	659475	4592	999547	10	659928	4602	340072	23
38	662230	4563	999541	10	662689	4573	337311	22
39	664968	4535	999535	10	665433	4544	334567	21
40	667689	4506	999529	10	668160	4526	331840	20
41	8.670393	4479	9.999524	10	8.670870	4488	11.329130	19
42	673080	4451	999518	10	673563	4461	326437	18
43	675751	4424	999512	10	676239	4434	323761	17
44	678405	4397	999506	10	678900	4417	321100	16
45	681043	4370	999500	10	681544	4380	318456	15
46	683665	4344	999493	10	684172	4354	315828	14
47	686272	4318	999487	10	686784	4328	313216	13
48	688863	4292	999481	10	689381	4303	310619	12
49	691438	4267	999475	10	691963	4277	308037	11
50	693998	4242	999469	10	694529	4252	305471	10
51	8.696543	4217	9.999463	11	8.697081	4228	11.302919	9
52	699073	4192	999456	11	699617	4203	300383	8
53	701589	4168	999450	11	702139	4179	297861	7
54	704090	4144	999443	11	704646	4155	295354	6
55	706577	4121	999437	11	707140	4132	292860	5
56	709049	4097	999431	11	709618	4108	290382	4
57	711507	4074	999424	11	712083	4085	287917	3
58	713952	4051	999418	11	714534	4062	285465	2
59	716383	4029	999411	11	716972	4040	283028	1
60	718800	4006	999404	11	719396	4017	280604	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8.718800	4006	9.999404	11	8.719396	4017	11.280604	60
1	721204	3984	999398	11	721806	3995	278194	59
2	723595	3962	999391	11	724204	3974	275796	58
3	725972	3941	999384	11	726588	3952	273412	57
4	728337	3919	999378	11	728959	3930	271041	56
5	730688	3898	999371	11	731317	3909	268683	55
6	733027	3877	999364	12	733663	3889	266337	54
7	735354	3857	999357	12	735996	3868	264004	53
8	737667	3836	999350	12	738317	3848	261683	52
9	739969	3816	999343	12	740626	3827	259374	51
10	742259	3796	999336	12	742922	3807	257078	50
11	8.744536	3776	9.999329	12	8.745207	3787	11.254793	49
12	746802	3756	999322	12	747479	3768	252521	48
13	749055	3737	999315	12	749740	3749	250260	47
14	751297	3717	999308	12	751989	3729	248011	46
15	753528	3698	999301	12	754227	3710	245773	45
16	755747	3679	999294	12	756453	3692	243547	44
17	757955	3661	999286	12	758668	3673	241332	43
18	760151	3642	999279	12	760872	3655	239128	42
19	762337	3624	999272	12	763065	3636	236935	41
20	764511	3606	999265	12	765246	3618	234754	40
21	8.766675	3588	9.999257	12	8.767417	3600	11.232583	39
22	768828	3570	999250	13	769578	3583	230422	38
23	770970	3553	999242	13	771727	3565	228273	37
24	773101	3535	999235	13	773866	3548	226134	36
25	775223	3518	999227	13	775995	3531	224005	35
26	777333	3501	999220	13	778114	3514	221886	34
27	779434	3484	999212	13	780222	3497	219778	33
28	781524	3467	999205	13	782320	3480	217680	32
29	783605	3451	999197	13	784408	3464	215592	31
30	785675	3431	999189	13	786486	3447	213514	30
31	8.787736	3418	9.999181	13	8.788554	3431	11.211446	29
32	789787	3402	999174	13	790613	3414	209387	28
33	791828	3386	999166	13	792662	3399	207338	27
34	793859	3370	999158	13	794701	3383	205299	26
35	795881	3354	999150	13	796731	3368	203269	25
36	797894	3339	999142	13	798752	3352	201248	24
37	799897	3323	999134	13	800763	3337	199237	23
38	801892	3308	999126	13	802765	3322	197235	22
39	803876	3293	999118	13	804758	3307	195242	21
40	805852	3278	999110	13	806742	3292	193258	20
41	8.807819	3263	9.999102	13	8.808717	3278	11.191283	19
42	809777	3249	999094	14	810683	3262	189317	18
43	811726	3234	999086	14	812641	3248	187359	17
44	813667	3219	999077	14	814589	3233	185411	16
45	815599	3205	999069	14	816529	3219	183471	15
46	817522	3191	999061	14	818461	3205	181539	14
47	819436	3177	999053	14	820384	3191	179616	13
48	821343	3163	999044	14	822298	3177	177702	12
49	823240	3149	999036	14	824205	3163	175795	11
50	825130	3135	999027	14	826103	3150	173897	10
51	8.827011	3122	9.999019	14	8.827992	3136	11.172008	9
52	828884	3108	999010	14	829874	3123	170126	8
53	830749	3095	999002	14	831748	3110	168252	7
54	832607	3082	998993	14	833613	3096	166387	6
55	834456	3069	998984	14	835471	3083	164529	5
56	836297	3056	998976	14	837321	3070	162679	4
57	838130	3043	998967	15	839163	3057	160837	3
58	839956	3030	998958	15	840998	3045	159002	2
59	841774	3017	998950	15	842825	3032	157175	1
60	843585	3000	998941	15	844644	3019	155356	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8.843585	3005	9.998941	15	8.844644	3019	11.155356	60
1	845387	2992	998932	15	846455	3007	153545	59
2	847183	2980	998923	15	848260	2995	151740	58
3	848971	2967	998914	15	850057	2982	149943	57
4	850751	2955	998905	15	851846	2970	148154	56
5	852525	2943	998896	15	853628	2958	146372	55
6	854291	2931	998887	15	855403	2946	144597	54
7	856049	2919	998878	15	857171	2935	142829	53
8	857801	2907	998869	15	858932	2923	141068	52
9	859546	2896	998860	15	860686	2911	139314	51
10	861283	2884	998851	15	862433	2900	137567	50
11	8.863014	2873	9.998841	15	8.864173	2888	11.135827	49
12	864738	2861	998832	15	865906	2877	134094	48
13	866455	2850	998823	16	867632	2866	132368	47
14	868165	2839	998813	16	869351	2854	130649	46
15	869868	2828	998804	16	871064	2843	128936	45
16	871565	2817	998795	16	872770	2832	127230	44
17	873255	2806	998785	16	874469	2821	125531	43
18	874938	2795	998776	16	876162	2811	123838	42
19	876615	2786	998766	16	877849	2800	122151	41
20	878285	2773	998757	16	879529	2789	120471	40
21	8.879949	2763	9.998747	16	8.881202	2779	11.118798	39
22	881607	2752	998738	16	882869	2768	117131	38
23	883258	2742	998728	16	884530	2758	115470	37
24	884903	2731	998718	16	886185	2747	113815	36
25	886542	2721	998708	16	887833	2737	112167	35
26	888174	2711	998699	16	889476	2727	110524	34
27	889801	2700	998689	16	891112	2717	108888	33
28	891421	2690	998679	16	892742	2707	107258	32
29	893035	2680	998669	17	894366	2697	105634	31
30	894643	2670	998659	17	895984	2687	104016	30
31	8.896246	2660	9.998649	17	8.897596	2677	11.102404	29
32	897842	2651	998639	17	899203	2667	100797	28
33	899432	2641	998629	17	900803	2658	099197	27
34	901017	2631	998619	17	902398	2648	097602	26
35	902596	2622	998609	17	903987	2638	096013	25
36	904169	2612	998599	17	905570	2629	094430	24
37	905736	2603	998589	17	907147	2620	092853	23
38	907297	2593	998578	17	908719	2610	091281	22
39	908853	2584	998568	17	910285	2601	089715	21
40	910404	2575	998558	17	911846	2592	088154	20
41	8.911949	2566	9.998548	17	8.913401	2583	11.086599	19
42	913488	2556	998537	17	914951	2574	085049	18
43	915022	2547	998527	17	916495	2565	083505	17
44	916550	2538	998516	18	918034	2556	081966	16
45	918073	2529	998506	18	919568	2547	080432	15
46	919591	2520	998495	18	921096	2538	078904	14
47	921103	2512	998485	18	922619	2530	077381	13
48	922610	2503	998474	18	924136	2521	075864	12
49	924112	2494	998464	18	925649	2512	074351	11
50	925609	2486	998453	18	927156	2503	072844	10
51	8.927100	2477	9.998442	18	8.928658	2495	11.071342	9
52	928587	2469	998431	18	930155	2486	069845	8
53	930068	2460	998421	18	931647	2478	068353	7
54	931544	2452	998410	18	933134	2470	066866	6
55	933015	2443	998399	18	934616	2461	065384	5
56	934481	2435	998388	18	936093	2453	063907	4
57	935942	2427	998377	18	937565	2445	062435	3
58	937398	2419	998366	18	939032	2437	060968	2
59	938850	2411	998355	18	940494	2430	059506	1
60	940296	2403	998344	18	941952	2421	058048	0
	Cosine		Sine		Cotang.		Tang.	M.

M	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	8.940296	2403	9.998344	19	8.941952	2421	11.058048	60
1	941738	2394	998333	19	943404	2413	056596	59
2	943174	2387	998322	19	944852	2405	055148	58
3	944606	2379	998311	19	946295	2397	053705	57
4	946034	2371	998300	19	947734	2390	052266	56
5	947456	2363	998289	19	949168	2382	050832	55
6	948874	2355	998277	19	950597	2374	049403	54
7	950287	2348	998266	19	952021	2366	047979	53
8	951696	2340	998255	19	953441	2360	046559	52
9	953100	2332	998243	19	954856	2351	045144	51
10	954499	2325	998232	19	956267	2344	043733	50
11	8.955894	2317	9.998220	19	8.957674	2337	11.042326	49
12	957284	2310	998209	19	959075	2329	040925	48
13	958670	2302	998197	19	960473	2323	039527	47
14	960052	2295	998186	19	961866	2314	038134	46
15	961429	2288	998174	19	963255	2307	036745	45
16	962801	2280	998163	19	964639	2300	035361	44
17	964170	2273	998151	19	966019	2293	033981	43
18	965534	2266	998139	20	967394	2286	032606	42
19	966893	2259	998128	20	968766	2279	031234	41
20	968249	2252	998116	20	970133	2271	029867	40
21	8.969600	2244	9.998104	20	8.971496	2265	11.028504	39
22	970947	2238	998092	20	972855	2257	027145	38
23	972289	2231	998080	20	974209	2251	025791	37
24	973628	2224	998068	20	975560	2244	024440	36
25	974962	2217	998056	20	976906	2237	023094	35
26	976293	2210	998044	20	978248	2230	021752	34
27	977619	2203	998032	20	979586	2223	020414	33
28	978941	2197	998020	20	980921	2217	019079	32
29	980259	2190	998008	20	982251	2210	017749	31
30	981573	2183	997996	20	983577	2204	016423	30
31	8.982883	2177	9.997984	20	8.984899	2197	11.015101	29
32	984189	2170	997972	20	986217	2191	013783	28
33	985491	2163	997959	20	987532	2184	012468	27
34	986789	2157	997947	20	988842	2178	011158	26
35	988083	2150	997935	21	990149	2171	009851	25
36	989374	2144	997922	21	991451	2165	008549	24
37	990660	2138	997910	21	992750	2158	007250	23
38	991943	2131	997897	21	994045	2152	005955	22
39	993222	2125	997885	21	995337	2146	004663	21
40	994497	2119	997872	21	996624	2140	003376	20
41	8.995768	2112	9.997860	21	8.997908	2134	11.002092	19
42	997036	2106	997847	21	999188	2127	000812	18
43	998299	2100	997835	21	9.000465	2121	10.999535	17
44	999560	2094	997822	21	001738	2115	998262	16
45	9.000816	2087	997809	21	003007	2109	996993	15
46	002069	2082	997797	21	004272	2103	995728	14
47	003318	2076	997784	21	005534	2097	994466	13
48	004563	2070	997771	21	006792	2091	993208	12
49	005805	2064	997758	21	008047	2085	991953	11
50	007044	2058	997745	21	009298	2080	990702	10
51	9.008278	2052	9.997732	21	9.010546	2074	10.989454	9
52	009510	2046	997719	21	011790	2068	988210	8
53	010737	2040	997706	21	013031	2062	986969	7
54	011962	2034	997693	22	014268	2056	985732	6
55	013182	2029	997680	22	015502	2051	984498	5
56	014400	2023	997667	22	016732	2045	983268	4
57	015613	2017	997654	22	017959	2040	982041	3
58	016824	2012	997641	22	019183	2033	980817	2
59	018031	2006	997628	22	020403	2028	979597	1
60	019235	2000	997614	22	021620	2023	978380	0
	Cosine		Sine		Cotang.		Tang.	M

17 84 Degrees.

M	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.019235	2000	9.997614	22	9.021620	2023	10.978380	60
1	020435	1995	997601	22	022834	2017	977166	59
2	021632	1989	997588	22	024044	2011	975956	58
3	022825	1984	997574	22	025251	2006	974749	57
4	024016	1978	997561	22	026455	2000	973545	56
5	025203	1973	997547	22	027655	1995	972345	55
6	026386	1967	997534	23	028852	1990	971148	54
7	027567	1962	997520	23	030046	1985	969954	53
8	028744	1957	997507	23	031237	1979	968763	52
9	029918	1951	997493	23	032425	1974	967575	51
10	031089	1947	997480	23	033609	1969	966391	50
11	9.032257	1941	9.997466	23	9.034791	1964	10.965209	49
12	033421	1936	997452	23	035969	1958	964031	48
13	034582	1930	997439	23	037144	1953	962856	47
14	035741	1925	997425	23	038316	1948	961684	46
15	036896	1920	997411	23	039485	1943	960515	45
16	038048	1915	997397	23	040651	1938	959349	44
17	039197	1910	997383	23	041813	1933	958187	43
18	040342	1905	997369	23	042973	1928	957027	42
19	041485	1899	997355	23	044130	1923	955870	41
20	042625	1894	997341	23	045284	1918	954716	40
21	9.043762	1889	9.997327	24	9.046434	1913	10.953566	39
22	044895	1884	997313	24	047582	1908	952418	38
23	046026	1879	997299	24	048727	1903	951273	37
24	047154	1875	997285	24	049869	1898	950131	36
25	048279	1870	997271	24	051008	1893	948992	35
26	049400	1865	997257	24	052144	1889	947856	34
27	050519	1860	997242	24	053277	1884	946723	33
28	051635	1855	997228	24	054407	1879	945593	32
29	052749	1850	997214	24	055535	1874	944465	31
30	053859	1845	997199	24	056659	1870	943341	30
31	054966	1841	9.997185	24	9.057781	1865	10.942219	29
32	056071	1836	997170	24	058900	1869	941100	28
33	057172	1831	997156	24	060016	1855	939984	27
34	058271	1827	997141	24	061130	1851	938870	26
35	059367	1822	997127	24	062240	1846	937760	25
36	060460	1817	997112	24	063348	1842	936652	24
37	061551	1813	997098	24	064453	1837	935547	23
38	062639	1808	997083	25	065556	1838	934444	22
39	063724	1804	997068	25	066655	1828	933345	21
40	064806	1799	997053	25	067752	1824	932248	20
41	9.065885	1794	9.997039	25	9.068846	1819	10.931154	19
42	066962	1790	997024	25	069938	1815	930062	18
43	068036	1786	997009	25	071027	1810	928973	17
44	069107	1781	996994	25	072113	1806	927887	16
45	070176	1777	996979	25	073197	1802	926803	15
46	071242	1772	996964	25	074278	1797	925722	14
47	072306	1768	996949	25	075356	1793	924644	13
48	073366	1763	996934	25	076432	1789	923568	12
49	074424	1759	996919	25	077505	1784	922495	11
50	075480	1755	996904	25	078576	1780	921424	10
51	9.076533	1750	9.996889	25	9.079644	1776	10.920356	9
52	077583	1746	996874	25	080710	1772	919290	8
53	078631	1742	996858	25	081773	1767	918227	7
54	079676	1738	996843	25	082833	1763	917167	6
55	080719	1733	996828	25	083891	1759	916109	5
56	081759	1729	996812	26	084947	1755	915053	4
57	082797	1725	996797	26	086000	1751	914000	3
58	083832	1721	996782	26	087050	1747	912950	2
59	084864	1717	996766	26	088098	1743	911902	1
60	085894	1713	996751	26	089144	1738	910856	0
	Cosine		Sine		Co.tang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.085894	1713	9.996751	26	9.089144	1738	10.910856	60
1	086922	1709	996735	26	090187	1734	909813	59
2	087947	1704	996720	26	091228	1730	908772	58
3	088970	1700	996704	26	092266	1727	907734	57
4	089990	1696	996688	26	093302	1722	906698	56
5	091008	1692	996673	26	094336	1719	905664	55
6	092024	1688	996657	26	095367	1715	904633	54
7	093037	1684	996641	26	096395	1711	903605	53
8	094047	1680	996625	26	097422	1707	902578	52
9	095056	1676	996610	26	098446	1703	901554	51
10	096062	1673	996594	26	099468	1699	900532	50
11	9.097065	1668	9.996578	27	9.100487	1695	10.899513	49
12	098066	1665	996562	27	101504	1691	898496	48
13	099065	1661	996546	27	102519	1687	897481	47
14	100062	1657	996530	27	103532	1684	896468	46
15	101056	1653	996514	27	104542	1680	895458	45
16	102048	1649	996498	27	105550	1676	894450	44
17	103037	1645	996482	27	106556	1672	893444	43
18	104025	1641	996465	27	107559	1669	892441	42
19	105010	1638	996449	27	108560	1665	891440	41
20	105992	1634	996433	27	109559	1661	890441	40
21	9.106973	1630	9.996417	27	9.110556	1658	10.889444	39
22	107951	1627	996400	27	111551	1654	888449	38
23	108927	1623	996384	27	112543	1650	887457	37
24	109901	1619	996368	27	113533	1646	886467	36
25	110873	1616	996351	27	114521	1643	885479	35
26	111842	1612	996335	27	115507	1639	884493	34
27	112809	1608	996318	27	116491	1636	883509	33
28	113774	1605	996302	28	117472	1632	882528	32
29	114737	1601	996285	28	118452	1629	881548	31
30	115698	1597	996269	28	119429	1625	880571	30
31	9.116656	1594	9.996252	28	9.120404	1622	10.879596	29
32	117613	1590	996235	28	121377	1618	878623	28
33	118567	1587	996219	28	122348	1615	877652	27
34	119519	1583	996202	28	123317	1611	876683	26
35	120469	1580	996185	28	124284	1607	875716	25
36	121417	1576	996168	28	125249	1604	874751	24
37	122362	1573	996151	28	126211	1601	873789	23
38	123306	1569	996134	28	127172	1597	872828	22
39	124248	1566	996117	28	128130	1594	871870	21
40	125187	1562	996100	28	129087	1591	870913	20
41	9.126125	1559	9.996083	29	9.130041	1587	10.869959	19
42	127060	1556	996066	29	130994	1584	869006	18
43	127993	1552	996049	29	131944	1581	868056	17
44	128925	1549	996032	29	132893	1577	867107	16
45	129854	1545	996015	29	133839	1574	866161	15
46	130781	1542	995998	29	134784	1571	865216	14
47	131706	1539	995980	29	135726	1567	864274	13
48	132630	1535	995963	29	136667	1564	863333	12
49	133551	1532	995946	29	137605	1561	862395	11
50	134470	1529	995928	29	138542	1558	861458	10
51	9.135387	1525	9.995911	29	9.139476	1555	10.860524	9
52	136303	1522	995894	29	140409	1551	859591	8
53	137216	1519	995876	29	141340	1548	858660	7
54	138128	1516	995859	29	142269	1545	857731	6
55	139037	1512	995841	29	143196	1542	856804	5
56	139944	1509	995823	29	144121	1539	855879	4
57	140850	1506	995806	29	145044	1535	854956	3
58	141754	1503	995788	29	145966	1532	854034	2
59	142655	1500	995771	29	146885	1529	853115	1
60	143555	1496	995753	29	147803	1526	852197	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.143555	1496	9.995753	30	9.147803	1526	10.852197	60
1	144453	1493	995735	30	148718	1523	851282	59
2	145349	1490	995717	30	149632	1520	850368	58
3	146243	1487	995699	30	150544	1517	849456	57
4	147136	1484	995681	30	151454	1514	848546	56
5	148026	1481	995664	30	152363	1511	847637	55
6	148915	1478	995646	30	153269	1508	846731	54
7	149802	1475	995628	30	154174	1505	845826	53
8	150686	1472	995610	30	155077	1502	844923	52
9	151569	1469	995591	30	155978	1499	844022	21
10	152451	1466	995573	30	156877	1496	843123	50
11	9 153330	1463	9.995555	30	9.157775	1493	10.842225	49
12	154208	1460	995537	30	158671	1490	841329	48
13	155083	1457	995519	30	159565	1487	840435	47
14	155957	1454	995501	31	160457	1484	839543	46
15	156830	1451	995482	31	161347	1481	838653	45
16	157700	1448	995464	31	162236	1479	837764	44
17	158569	1445	995446	31	163123	1476	836877	43
18	159435	1442	995427	31	164008	1473	835992	42
19	160301	1439	995409	31	164892	1470	835108	41
20	161164	1436	995390	31	165774	1467	834226	40
21	9.162025	1433	9.995372	31	9.166654	1464	10.833346	39
22	162885	1430	995353	31	167532	1461	832468	38
23	163743	1427	995334	31	168409	1458	831591	37
24	164600	1424	995316	31	169284	1455	830716	36
25	165454	1422	995297	31	170157	1453	829843	35
26	166307	1419	995278	31	171029	1450	828971	34
27	167159	1416	995260	31	171899	1447	828101	33
28	168008	1413	995241	32	172767	1444	827233	32
29	168856	1410	995222	32	173634	1442	826366	31
30	169702	1407	995203	32	174499	1439	825501	30
31	9.170547	1405	9.995184	32	9.175362	1436	10.824638	29
32	171389	1402	995165	32	176224	1433	823776	28
33	172230	1399	995146	32	177084	1431	822916	27
34	173070	1396	995127	32	177942	1428	822058	26
35	173908	1394	995108	32	178799	1425	821201	25
36	174744	1391	995089	32	179655	1423	820345	24
37	175578	1388	995070	32	180508	1420	819492	23
38	176411	1386	995051	32	181360	1417	818640	22
39	177242	1383	995032	32	182211	1415	817789	21
40	178072	1380	995013	32	183059	1412	816941	20
41	9.178900	1377	9.994993	32	9.183907	1409	10.816093	19
42	179726	1374	994974	32	184752	1407	815248	18
43	180551	1372	994955	32	185597	1404	814403	17
44	181374	1369	994935	32	186439	1402	813561	16
45	182196	1366	994916	33	187280	1399	812720	15
46	183016	1364	994896	33	188120	1396	811880	14
47	183834	1361	994877	33	188958	1393	811042	13
48	184651	1359	994857	33	189794	1391	810206	12
49	185466	1356	994838	33	190629	1389	809371	11
50	186280	1353	994818	33	191462	1386	808538	10
51	9.187092	1351	9.994798	33	9.192294	1384	10.807706	9
52	187903	1348	994779	33	193124	1381	806876	8
53	188712	1346	994759	33	193953	1379	806047	7
54	189519	1343	994739	33	194780	1376	805220	6
55	190325	1341	994719	33	195606	1374	804394	5
56	191130	1338	994700	33	196430	1371	803570	4
57	191933	1336	994680	33	197253	1369	802747	3
58	192734	1333	994660	33	198074	1366	801926	2
59	193534	1330	994640	33	198894	1364	801106	1
60	194332	1328	994620	33	199713	1361	800287	0
	Cosine		Sine		Cotang.		Tang.	M.

81 Degrees.

M.	Sine	D.	Cosine	D	Tang.	D.	Cotang.	
0	9.194332	1328	9.994620	33	9.199713	1361	10.800287	60
1	195129	1326	994600	33	200529	1359	799471	59
2	195925	1323	994580	33	201345	1356	798655	58
3	196719	1321	994560	34	202159	1354	797841	57
4	197511	1318	994540	34	202971	1352	797029	56
5	198302	1316	994519	34	203782	1349	796218	55
6	199091	1313	994499	34	204592	1347	795408	54
7	199879	1311	994479	34	205400	1345	794600	53
8	200666	1308	994459	34	206207	1342	793793	52
9	201451	1306	994438	34	207013	1340	792987	51
10	202234	1304	994418	34	207817	1338	792183	50
11	9.203017	1301	9.994397	34	9.208619	1335	10.791381	49
12	203797	1299	994377	34	209420	1333	790580	48
13	204577	1296	994357	34	210220	1331	789780	47
14	205354	1294	994336	34	211018	1328	788982	46
15	206131	1292	994316	34	211815	1326	788185	45
16	206906	1289	994295	34	212611	1324	787389	44
17	207679	1287	994274	35	213405	1321	786595	43
18	208452	1285	994254	35	214198	1319	785802	42
19	209222	1282	994233	35	214989	1317	785011	41
20	209992	1280	994212	35	215780	1315	784220	40
21	9.210760	1278	9.994191	35	9.216568	1312	10.783432	39
22	211526	1275	994171	35	217356	1310	782644	38
23	212291	1273	994150	35	218142	1308	781858	37
24	213055	1271	994129	35	218926	1305	781074	36
25	213818	1268	994108	35	219710	1303	780290	35
26	214579	1266	994087	35	220492	1301	779508	34
27	215338	1264	994066	35	221272	1299	778728	33
28	216097	1261	994045	35	222052	1297	777948	32
29	216854	1259	994024	35	222830	1294	777170	31
30	217609	1257	994003	35	223606	1292	776394	30
31	9.218363	1255	9.993981	35	9.224382	1290	10.775618	29
32	219116	1253	993960	35	225156	1288	774844	28
33	219868	1250	993939	35	225929	1286	774071	27
34	220618	1248	993918	35	226700	1284	773300	26
35	221367	1246	993896	36	227471	1281	772529	25
36	222115	1244	993875	36	228239	1279	771761	24
37	222861	1242	993854	36	229007	1277	770993	23
38	223606	1239	993832	36	229773	1275	770227	22
39	224349	1237	993811	36	230539	1273	769461	21
40	225092	1235	993789	36	231302	1271	768698	20
41	9.225833	1233	9.993768	36	9.232065	1269	10.767935	19
42	226573	1231	993746	36	232826	1267	767174	18
43	227311	1228	993725	36	233586	1265	766414	17
44	228048	1226	993703	36	234345	1262	765655	16
45	228784	1224	993681	36	235103	1260	764897	15
46	229518	1222	993660	36	235859	1258	764141	14
47	230252	1220	993638	36	236614	1256	763386	13
48	230984	1218	993616	36	237368	1254	762632	12
49	231714	1216	993594	37	238120	1252	761880	11
50	232444	1214	993572	37	238872	1250	761128	10
51	9.233172	1212	9.993550	37	9.239622	1248	10.760378	9
52	233899	1209	993528	37	240371	1246	759629	8
53	234625	1207	993506	37	241118	1244	758882	7
54	235349	1205	993484	37	241865	1242	758135	6
55	236073	1203	993462	37	242610	1240	757390	5
56	236795	1201	993440	37	243354	1238	756646	4
57	237515	1199	993418	37	244097	1236	755903	3
58	238235	1197	993396	37	244839	1234	755161	2
59	238953	1195	993374	37	245579	1232	754421	1
60	239670	1193	993351	37	246319	1230	753681	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.239670	1193	9.993351	37	9.246319	1230	10.753681	60
1	240386	1191	993329	37	247057	1228	752943	59
2	241101	1189	993307	37	247794	1226	752206	58
3	241814	1187	993285	37	248530	1224	751470	57
4	242526	1185	993262	37	249264	1222	750736	56
5	243237	1183	993240	37	249998	1220	750002	55
6	243947	1181	993217	38	250730	1218	749270	54
7	244656	1179	993195	38	251461	1217	748539	53
8	245363	1177	993172	38	252191	1215	747809	52
9	246069	1175	993149	38	252920	1213	747080	51
10	246775	1173	993127	38	253648	1211	746352	50
11	9.247478	1171	9.993104	38	9.254374	1209	10.745626	49
12	248181	1169	993081	38	255100	1207	744900	48
13	248883	1167	993059	38	255824	1205	744176	47
14	249583	1165	993036	38	256547	1203	743453	46
15	250282	1163	993013	38	257269	1201	742731	45
16	250980	1161	992990	38	257990	1200	742010	44
17	251677	1159	992967	38	258710	1198	741290	43
18	252373	1158	992944	38	259429	1196	740571	42
19	253067	1156	992921	38	260146	1194	739854	41
20	253761	1154	992898	38	260863	1192	739137	40
21	9.254453	1152	9.992875	38	9.261578	1190	10.738422	39
22	255144	1150	992852	38	262292	1189	737708	38
23	255834	1148	992829	39	263005	1187	736995	37
24	256523	1146	992806	39	263717	1185	736283	36
25	257211	1144	992783	39	264428	1183	735572	35
26	257898	1142	992759	39	265138	1181	734862	34
27	258583	1141	992736	39	265847	1179	734153	33
28	259268	1139	992713	39	266555	1178	733445	32
29	259951	1137	992690	39	267261	1176	732739	31
30	260633	1135	992666	39	267967	1174	732033	30
31	9.261314	1133	9.992643	39	9.268671	1172	10.731329	29
32	261994	1131	992619	39	269375	1170	730625	28
33	262673	1130	992596	39	270077	1169	729923	27
34	263351	1128	992572	39	270779	1167	729221	26
35	264027	1126	992549	39	271479	1165	728521	25
36	264703	1124	992525	39	272178	1164	727822	24
37	265377	1122	992501	39	272876	1162	727124	23
38	266051	1120	992478	40	273573	1160	726427	22
39	266723	1119	992454	40	274269	1158	725731	21
40	267395	1117	992430	40	274964	1157	725036	20
41	9.268065	1115	9.992406	40	9.275658	1155	10.724342	19
42	268734	1113	992382	40	276351	1153	723649	18
43	269402	1111	992359	40	277043	1151	722957	17
44	270069	1110	992335	40	277734	1150	722266	16
45	270735	1108	992311	40	278424	1148	721576	15
46	271400	1106	992287	40	279113	1147	720887	14
47	272064	1105	992263	40	279801	1145	720199	13
48	272726	1103	992239	40	280488	1143	719512	12
49	273388	1101	992214	40	281174	1141	718826	11
50	274049	1099	992190	40	281858	1140	718142	10
51	9.274708	1098	9.992166	40	9.282542	1138	10.717458	9
52	275367	1096	992142	40	283225	1136	716775	8
53	276024	1094	992117	41	283907	1135	716093	7
54	276681	1092	992093	41	284588	1133	715412	6
55	277337	1091	992069	41	285268	1131	714732	5
56	277991	1089	992044	41	285947	1130	714053	4
57	278644	1087	992020	41	286624	1128	713376	3
58	279297	1086	991996	41	287301	1126	712699	2
59	279948	1084	991971	41	287977	1125	712023	1
60	280599	1082	991947	41	288652	1123	711348	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.280599	1082	9.991947	41	9.288652	1123	10.711348	60
1	281248	1081	991922	41	289326	1122	710674	59
2	281897	1079	991897	41	289999	1120	710001	58
3	282544	1077	991873	41	290671	1118	709329	57
4	283190	1076	991848	41	291342	1117	708658	56
5	283836	1074	991823	41	292013	1115	707987	55
6	284480	1072	991799	41	292682	1114	707318	54
7	285124	1071	991774	42	293350	1112	706650	53
8	285766	1069	991749	42	294017	1111	705983	52
9	286408	1067	991724	42	294684	1109	705316	51
10	287048	1066	991699	42	295349	1107	704651	50
11	9.287687	1064	9.991674	42	9.296013	1106	10.703987	49
12	288326	1063	991649	42	296677	1104	703323	48
13	288964	1061	991624	42	297339	1103	702661	47
14	289600	1059	991599	42	298001	1101	701999	46
15	290236	1058	991574	42	298662	1100	701338	45
16	290870	1056	991549	42	299322	1098	700678	44
17	291504	1054	991524	42	299980	1096	700020	43
18	292137	1053	991498	42	300638	1095	699362	42
19	292768	1051	991473	42	301295	1093	698705	41
20	293399	1050	991448	42	301951	1092	698049	40
21	9.294029	1048	9.991422	42	9.302607	1090	10.697393	39
22	294658	1046	991397	42	303261	1089	696739	38
23	295286	1045	991372	43	303914	1087	696086	37
24	295913	1043	991346	43	304567	1086	695433	36
25	296539	1042	991321	43	305218	1084	694782	35
26	297164	1040	991295	43	305869	1083	694131	34
27	297788	1039	991270	43	306519	1081	693481	33
28	298412	1037	991244	43	307168	1080	692832	32
29	299034	1036	991218	43	307816	1078	692185	31
30	299655	1034	991193	43	308463	1077	691537	30
31	9.300276	1032	9.991167	43	9.309109	1075	10.690891	29
32	300895	1031	991141	43	309754	1074	690246	28
33	301514	1029	991115	43	310398	1073	689602	27
34	302132	1028	991090	43	311042	1071	688958	26
35	302748	1026	991064	43	311685	1070	688315	25
36	303364	1025	991038	43	312327	1068	687673	24
37	303979	1023	991012	43	312967	1067	687033	23
38	304593	1022	990986	43	313608	1065	686392	22
39	305207	1020	990960	43	314247	1064	685753	21
40	305819	1019	990934	44	314885	1062	685115	20
41	9.306430	1017	9.990908	44	9.315523	1061	10.684477	19
42	307041	1016	990882	44	316159	1060	683841	18
43	307650	1014	990855	44	316795	1058	683205	17
44	308259	1013	990829	44	317430	1057	682570	16
45	308867	1011	990803	44	318064	1055	681936	15
46	309474	1010	990777	44	318697	1054	681303	14
47	310080	1008	990750	44	319329	1053	680671	13
48	310685	1007	990724	44	319961	1051	680039	12
49	311289	1005	990697	44	320592	1050	679408	11
50	311893	1004	990671	44	321222	1048	678778	10
51	9.312495	1003	9.990644	44	9.321851	1047	10.678149	9
52	313097	1001	990618	44	322479	1045	677521	8
53	313698	1000	990591	44	323106	1044	676894	7
54	314297	998	990565	44	323733	1043	676267	6
55	314897	997	990538	44	324358	1041	675642	5
56	315495	996	990511	45	324983	1040	675017	4
57	316092	994	990485	45	325607	1039	674393	3
58	316689	993	990458	45	326231	1037	673769	2
59	317284	991	990431	45	326853	1036	673147	1
60	317879	990	990404	45	327475	1035	672525	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.317879	990	9.990404	45	9.327474	1035	10.672526	60
1	318473	988	990378	45	328095	1033	671905	59
2	319066	987	990351	45	328715	1032	671285	58
3	319658	986	990324	45	329334	1030	670666	57
4	320249	984	990297	45	329953	1029	670047	56
5	320840	983	990270	45	330570	1028	669430	55
6	321430	982	990243	45	331187	1026	668813	54
7	322019	980	990215	45	331803	1025	668197	53
8	322607	979	990188	45	332418	1024	667582	52
9	323194	977	990161	45	333033	1023	666967	51
10	323780	976	990134	45	333646	1021	666354	50
11	9.324366	975	9.990107	46	9.334259	1020	10.665741	49
12	324950	973	990079	46	334871	1019	665129	48
13	325534	972	990052	46	335482	1017	664518	47
14	326117	970	990025	46	336093	1016	663907	46
15	326700	969	989997	46	336702	1015	663298	45
16	327281	968	989970	46	337311	1013	662689	44
17	327862	966	989942	46	337919	1012	662081	43
18	328442	965	989915	46	338527	1011	661473	42
19	329021	964	989887	46	339133	1010	660867	41
20	329599	962	989860	46	339739	1008	660261	40
21	9.330176	961	9.989832	46	9.340344	1007	10.659656	39
22	330753	960	989804	46	340948	1006	659052	38
23	331329	958	989777	46	341552	1004	658448	37
24	331903	957	989749	47	342155	1003	657845	36
25	332478	956	989721	47	342757	1002	657243	35
26	333051	954	989693	47	343358	1000	656642	34
27	333624	953	989665	47	343958	999	656042	33
28	334195	952	989637	47	344558	998	655442	32
29	334766	950	989609	47	345157	997	654843	31
30	335337	949	989582	47	345755	996	654245	30
31	9.335906	948	9.989553	47	9.346353	994	10.653647	29
32	336475	946	989525	47	346949	993	653051	28
33	337043	945	989497	47	347545	992	652455	27
34	337610	944	989469	47	348141	991	651859	26
35	338176	943	989441	47	348735	990	651265	25
36	338742	941	989413	47	349329	988	650671	24
37	339306	940	989384	47	349922	987	650078	23
38	339871	939	989356	47	350514	986	649480	22
39	340434	937	989328	47	351106	985	648894	21
40	340996	936	989300	47	351697	983	648303	20
41	9.341558	935	9.989271	47	9.352287	982	10.647713	19
42	342119	934	989243	47	352876	981	647124	18
43	342679	932	989214	47	353465	980	646535	17
44	343239	931	989186	47	354053	979	645947	16
45	343797	930	989157	47	354640	977	645360	15
46	344355	929	989128	48	355227	976	644773	14
47	344912	927	989100	48	355813	975	644187	13
48	345469	926	989071	48	356398	974	643602	12
49	346024	925	989042	48	356982	973	643018	11
50	346579	924	989014	48	357566	971	642434	10
31	9.347134	922	9.988985	48	9.358149	970	10.641851	9
52	347687	921	988956	48	358731	969	641269	8
53	348240	920	988927	48	359313	968	640687	7
54	348792	919	988898	48	359893	967	640107	6
55	349343	917	988869	48	360474	966	639526	5
56	349893	916	988840	48	361053	965	638947	4
57	350443	915	988811	49	361632	963	638368	3
58	350992	914	988782	49	362210	962	637790	2
59	351540	913	988753	49	362787	961	637213	1
60	352088	911	988724	49	363364	960	636636	0
	Cosine		Sine		Cotang.		Tang	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.352088	911	9.988724	49	9.363364	960	10.636636	60
1	352635	910	988695	49	363940	959	636060	59
2	353181	909	988666	49	364515	958	635485	58
3	353726	908	988636	49	365090	957	631910	57
4	354271	907	988607	49	365664	955	634336	56
5	354815	905	988578	49	366237	954	633763	55
6	355358	904	988548	49	366810	953	633190	54
7	355901	903	988519	49	367382	952	632618	53
8	356443	902	988489	49	367953	951	632047	52
9	356984	901	988460	49	368524	950	631476	51
10	357524	899	988430	49	369094	949	630906	50
11	9.358064	898	9.988401	49	9.369663	948	10.630337	49
12	358603	897	988371	49	370232	946	629768	48
13	359141	896	988342	49	370799	945	629201	47
14	359678	895	988312	50	371367	944	628633	46
15	360215	893	988282	50	371933	943	623067	45
16	360752	892	988252	50	372499	942	627501	44
17	361287	891	988223	50	373064	941	626936	43
18	361822	890	988193	50	373629	940	626371	42
19	362356	889	988163	50	374193	939	625807	41
20	362889	888	988133	50	374756	938	625244	40
21	9.363422	887	9.988103	50	9.375319	937	10.624681	39
22	363954	885	988073	50	375881	935	624119	38
23	364485	884	988043	50	376442	934	623558	37
24	365016	883	988013	50	377003	933	622997	36
25	365546	882	987983	50	377563	932	622437	35
26	366075	881	987953	50	378122	931	621878	34
27	366604	880	987922	50	378681	930	621319	33
28	367131	879	987892	50	379239	929	620761	32
29	367659	877	987862	50	379797	928	620203	31
30	368185	876	987832	51	380354	927	619646	30
31	9.368711	875	9.987801	51	9.380910	926	10.619090	29
32	369236	874	987771	51	381466	925	618534	28
33	369761	873	987740	51	382020	924	617980	27
34	370285	872	987710	51	382575	923	617425	26
35	370808	871	987679	51	383129	922	616871	25
36	371330	870	987649	51	383682	921	616318	24
37	371852	869	987618	51	384234	920	615766	23
38	372373	867	987588	51	384786	919	615214	22
39	372894	866	987557	51	385337	918	614663	21
40	373414	865	987526	51	385888	917	614112	20
41	9.373933	864	9.987496	51	9.386438	915	10.613562	19
42	374452	863	987465	51	386987	914	613013	18
43	374970	862	987434	51	387536	913	612464	17
44	375487	861	987403	52	388084	912	611916	16
45	376003	860	987372	52	388631	911	611369	15
46	376519	859	987341	52	389178	910	610822	14
47	377035	858	997310	52	389724	909	610276	13
48	377549	857	987279	52	390270	908	609730	12
49	378063	856	987248	52	390815	907	609185	11
50	378577	854	987217	52	391360	906	608640	10
51	9.379089	853	9.987186	52	9.391903	905	10.608097	9
52	379601	852	987155	52	392447	904	607553	8
53	380113	851	987124	52	392989	903	607011	7
54	380624	850	987092	52	393531	902	606469	6
55	381134	849	987061	52	394073	901	605927	5
56	381643	848	987030	52	394614	900	605386	4
57	382152	847	986998	52	395154	899	604846	3
58	382661	846	986967	52	395694	898	604306	2
59	383168	845	986936	52	396233	897	603767	1
60	383675	844	986904	52	396771	896	603229	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.383675	844	9.986904	52	9.396771	896	10.603229	60
1	384182	843	986873	53	397309	896	602691	59
2	384687	842	986841	53	397846	895	602154	58
3	385192	841	986809	53	398383	894	601617	57
4	385697	840	986778	53	398919	893	601081	56
5	386201	839	986746	53	399455	892	600545	55
6	386704	838	986714	53	399990	891	600010	54
7	387207	837	986683	53	400524	890	599476	53
8	387709	836	986651	53	401058	889	598942	52
9	388210	835	986619	53	401591	888	598409	51
10	388711	834	986587	53	402124	887	597876	50
11	9.389211	833	9.986555	53	9.402656	886	10.597344	49
12	389711	832	986523	53	403187	885	596813	48
13	390210	831	986491	53	403718	884	596282	47
14	390708	830	986459	53	404249	883	595751	46
15	391206	828	986427	53	404778	882	595222	45
16	391703	827	986395	53	405308	881	594692	44
17	392199	826	986363	54	405836	880	594164	43
18	392695	825	986331	54	406364	879	593636	42
19	393191	824	986299	54	406892	878	593108	41
20	393685	823	986266	54	407419	877	592581	40
21	9.394179	822	9.986234	54	9.407945	876	10.592055	39
22	394673	821	986202	54	408471	875	591529	38
23	395166	820	986169	54	408997	874	591003	37
24	395658	819	986137	54	409521	874	590479	36
25	396150	818	986104	54	410045	873	589955	35
26	396641	817	986072	54	410569	872	589431	34
27	397132	817	986039	54	411092	871	588908	33
28	397621	816	986007	54	411615	870	588385	32
29	398111	815	985974	54	412137	869	587863	31
30	398600	814	985942	54	412658	868	587342	30
31	9.399088	813	9.985909	55	9.413179	867	10.586821	29
32	399575	812	985876	55	413699	866	586301	28
33	400062	811	985843	55	414219	865	585781	27
34	400549	810	985811	55	414738	864	585262	26
35	401035	809	985778	55	415257	864	584743	25
36	401520	808	985745	55	415775	863	584225	24
37	402005	807	985712	55	416293	862	583707	23
38	402489	806	985679	55	416810	861	583190	22
39	402972	805	985646	55	417326	860	582674	21
40	403455	804	985613	55	417842	859	582158	20
41	9.403938	803	9.985580	55	9.418358	858	10.581642	19
42	404420	802	985547	55	418873	857	581127	18
43	404901	801	985514	55	419387	856	580613	17
44	405382	800	985480	55	419901	855	580099	16
45	405862	799	985447	55	420415	855	579585	15
46	406341	798	985414	56	420927	854	579073	14
47	406820	797	985380	56	421440	853	578560	13
48	407299	796	985347	56	421952	852	578048	12
49	407777	795	985314	56	422463	851	577537	11
50	408254	794	985280	56	422974	850	577026	10
51	9.408731	794	9.985247	56	9.423484	849	10.576516	9
52	409207	793	985213	56	423993	848	576007	8
53	409682	792	985180	56	424503	848	575497	7
54	410157	791	985146	56	425011	847	574989	6
55	410632	790	985113	56	425519	846	574481	5
56	411106	789	985079	56	426027	845	573973	4
57	411579	788	985045	56	426534	844	573466	3
58	412052	787	985011	56	427041	843	572959	2
59	412524	786	984978	56	427547	843	572453	1
60	412996	785	984944	56	428052	842	571948	0
	Cosine		Sine		Cotang.		Tang	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.412996	785	9.984944	57	9.428052	842	10.571948	60
1	413467	784	984910	57	428557	841	571443	59
2	413938	783	984876	57	429062	840	570938	58
3	414408	783	984842	57	429566	839	570434	57
4	414878	782	984808	57	430070	838	569930	56
5	415347	781	984774	57	430573	838	569427	55
6	415815	780	984740	57	431075	837	568925	54
7	416283	779	984706	57	431577	836	568423	53
8	416751	778	984672	57	432079	835	567921	52
9	417217	777	984637	57	432580	834	567420	51
10	417684	776	984603	57	433080	833	566920	50
11	9.418150	775	9.984569	57	9.433580	832	10.566420	49
12	418615	774	984535	57	434080	832	565920	48
13	419079	773	984500	57	434579	831	565421	47
14	419544	773	984466	57	435078	830	564922	46
15	420007	772	984432	58	435576	829	564424	45
16	420470	771	984397	58	436073	828	563927	44
17	420933	770	984363	58	436570	828	563430	43
18	421395	769	984328	58	437067	827	562933	42
19	421857	768	984294	58	437563	826	562437	41
20	422318	767	984259	58	438059	825	561941	40
21	9.422778	767	9.984224	58	9.438554	824	10.561446	39
22	423238	766	984190	58	439048	823	560952	38
23	423697	765	984155	58	439543	823	560457	37
24	424156	764	984120	58	440036	822	559964	36
25	424615	763	984085	58	440529	821	559471	35
26	425073	762	984050	58	441022	820	558978	34
27	425530	761	984015	58	441514	819	558486	33
28	425987	760	983981	58	442006	819	557994	32
29	426443	760	983946	58	442497	818	557503	31
30	426899	759	983911	58	442988	817	557012	30
31	9.427354	758	9.983875	58	9.443479	816	10.556521	29
32	427809	757	983840	59	443968	816	556032	28
33	428263	756	983805	59	444458	815	555542	27
34	428717	755	983770	59	444947	814	555053	26
35	429170	754	983735	59	445435	813	554565	25
36	429623	753	983700	59	445923	812	554077	24
37	430075	752	983664	59	446411	812	553589	23
38	430527	752	983629	59	446898	811	553102	22
39	430978	751	983594	59	447384	810	552616	21
40	431429	750	983558	59	447870	809	552130	20
41	9.431879	749	9.983523	59	9.448356	809	10.551644	19
42	432329	749	983487	59	448841	808	551159	18
43	432778	748	983452	59	449326	807	550674	17
44	433226	747	983416	59	449810	806	550190	16
45	433675	746	983381	59	450294	806	549706	15
46	434122	745	983345	59	450777	805	549223	14
47	434569	744	983309	59	451260	804	548740	13
48	435016	744	983273	60	451743	803	548257	12
49	435462	743	983238	60	452225	802	547775	11
50	435908	742	983202	60	452706	802	547294	10
51	9.436353	741	9.983166	60	9.453187	801	10.546813	9
52	436798	740	983130	60	453668	800	546332	8
53	437242	740	983094	60	454148	799	545852	7
54	437686	739	983058	60	454628	799	545372	6
55	438129	738	983022	60	455107	798	544893	5
56	438572	737	982986	60	455586	797	544414	4
57	439014	736	982950	60	456064	796	543936	3
58	439456	736	982914	60	456542	796	543458	2
59	439897	735	982878	60	457019	795	542981	1
60	440338	734	982842	60	457496	794	542504	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.440338	734	9.982842	60	9.457496	794	10.542504	60
1	440778	733	982805	60	457973	793	542027	59
2	441218	732	982769	61	458449	793	541551	58
3	441658	731	982733	61	458925	792	541075	57
4	442096	731	982696	61	459400	791	540600	56
5	442535	730	982660	61	459875	790	540125	55
6	442973	729	982624	61	460349	790	539651	54
7	443410	728	982587	61	460823	789	539177	53
8	443847	727	982551	61	461297	788	538703	52
9	444284	727	982514	61	461770	788	538230	51
10	444720	726	982477	61	462242	787	537758	50
11	9.445155	725	9.982441	61	9.462714	786	10.537286	49
12	445590	724	982404	61	463186	785	536814	48
13	446025	723	982367	61	463658	785	536342	47
14	446459	723	982331	61	464129	784	535871	46
15	446893	722	982294	61	464599	783	535401	45
16	447326	721	982257	61	465069	783	534931	44
17	447759	720	982220	62	465539	782	534461	43
18	448191	720	982183	62	466008	781	533992	42
19	448623	719	982146	62	466476	780	533524	41
20	449054	718	982109	62	466945	780	533055	40
21	9.449485	717	9.982072	62	9.467413	779	10.532587	39
22	449915	716	982035	62	467880	778	532120	38
23	450345	716	981998	62	468347	778	531653	37
24	450775	715	981961	62	468814	777	531186	36
25	451204	714	981924	62	469280	776	530720	35
26	451632	713	981886	62	469746	775	530254	34
27	452060	713	981849	62	470211	775	529789	33
28	452488	712	981812	62	470676	774	529324	32
29	452915	711	981774	62	471141	773	528859	31
30	453342	710	981737	62	471605	773	528395	30
31	9.453768	710	9.981699	63	9.472068	772	10.527932	29
32	454194	709	981662	63	472532	771	527468	28
33	454619	708	981625	63	472995	771	527005	27
34	455044	707	981587	63	473457	770	526543	26
35	455469	707	981549	63	473919	769	526081	25
36	455893	706	981512	63	474381	769	525619	24
37	456316	705	981474	63	474842	768	525158	23
38	456739	704	981436	63	475303	767	524697	22
39	457162	704	981399	63	475763	767	524237	21
40	457584	703	981361	63	476223	766	523777	20
41	9.458006	702	9.981323	63	9.476683	765	10.523317	19
42	458427	701	981285	63	477142	765	522858	18
43	458848	701	981247	63	477601	764	522399	17
44	459268	700	981209	63	478059	763	521941	16
45	459688	699	981171	63	478517	763	521483	15
46	460108	698	981133	64	478975	762	521025	14
47	460527	698	981095	64	479432	761	520568	13
48	460946	697	981057	64	479889	761	520111	12
49	461364	696	981019	64	480345	760	519655	11
50	461782	695	980981	64	480801	759	519199	10
51	9.462199	695	9.980942	64	9.481257	759	10.518743	9
52	462616	694	980904	64	481712	758	518288	8
53	463032	693	980866	64	482167	757	517833	7
54	463448	693	980827	64	482621	757	517379	6
55	463864	692	980789	64	483075	756	516925	5
56	464279	691	980750	64	483529	755	516471	4
57	464694	690	980712	64	483982	755	516018	3
58	465108	690	980673	64	484435	754	515565	2
59	465522	689	980635	64	484887	753	515113	1
60	465935	688	980596	64	485339	753	514661	0
	Cosine		Sine		Cotang.		Tang.	M.

73 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.465935	688	9.980596	64	9.485339	755	10.514661	60
1	466348	688	980558	64	485791	752	514209	59
2	466761	687	980519	65	486242	751	513758	58
3	467173	686	980480	65	486693	751	513307	57
4	467585	685	980442	65	487143	750	512857	56
5	467996	685	980403	65	487593	749	512407	55
6	468407	684	980364	65	488043	749	511957	54
7	468817	683	980325	65	488492	748	511508	53
8	469227	683	980286	65	488941	747	511059	52
9	469637	682	980247	65	489390	747	510610	51
10	470046	681	980208	65	489838	746	510162	50
11	9.470455	680	9.980169	65	9.490286	746	10.509714	49
12	470863	680	980130	65	490733	745	509267	48
13	471271	679	980091	65	491180	744	508820	47
14	471679	678	980052	65	491627	744	508373	46
15	472086	678	980012	65	492073	743	507927	45
16	472492	677	979973	65	492519	743	507481	44
17	472898	676	979934	66	492965	742	507035	43
18	473204	676	979895	66	493410	741	506590	42
19	473710	675	979855	66	493854	740	506146	41
20	474115	674	979816	66	494299	740	505701	40
21	9.474519	674	9.979776	66	9.494743	740	10.505257	39
22	474923	673	979737	66	495186	739	504814	38
23	475327	672	979697	66	495630	738	504370	37
24	475730	672	979658	66	496073	737	503927	36
25	476133	671	979618	66	496515	737	503485	35
26	476536	670	979579	66	496957	736	503043	34
27	476938	669	979539	66	497399	736	502601	33
28	477340	669	979499	66	497841	735	502159	32
29	477741	668	979459	66	498282	734	501718	31
30	478142	667	979420	66	498722	734	501278	30
31	9.478542	667	9.979380	66	9.499163	733	10.500837	29
32	478942	666	979340	66	499603	733	500397	28
33	479342	665	979300	67	500042	732	499958	27
34	479741	665	979260	67	500481	731	499519	26
35	480140	664	979220	67	500920	731	499080	25
36	480539	663	979180	67	501359	730	498641	24
37	480937	663	979140	67	501797	730	498203	23
38	481334	662	979100	67	502235	729	497765	22
39	481731	661	979059	67	502672	728	497328	21
40	482128	661	979019	67	503109	728	496891	20
41	9.482525	660	9.978979	67	9.503546	727	10.496454	19
42	482921	659	978939	67	503982	727	496018	18
43	483316	659	978898	67	504418	726	495582	17
44	483712	658	978858	67	504854	726	495146	16
45	484107	657	978817	67	505289	725	494711	15
46	484501	657	978777	67	505724	724	494276	14
47	484895	656	978736	67	506159	724	493841	13
48	485289	655	978696	68	506593	723	493407	12
49	485682	655	978655	68	507027	722	492973	11
50	486075	654	978615	68	507460	722	492540	10
51	9.486467	653	9.978574	68	9.507893	721	10.492107	9
52	486860	653	978533	68	508326	721	491674	8
53	487251	652	978493	68	508759	720	491241	7
54	487643	651	978452	68	509191	719	490809	6
55	488034	651	978411	68	509622	719	490378	5
56	488424	650	978370	68	510054	718	489946	4
57	488814	650	978329	68	510485	718	489515	3
58	489204	649	978288	68	510916	717	489084	2
59	489593	648	978247	68	511346	716	488654	1
60	489982	648	978206	68	511776	716	488224	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D	Cotang.	
0	9.489982	648	9.978206	68	9.511776	716	10.488224	60
1	490371	648	978165	68	512206	716	487794	59
2	490759	647	978124	68	512635	715	487365	58
3	491147	646	978083	69	513064	714	486936	57
4	491535	646	978042	69	513493	714	486507	56
5	491922	645	978001	69	513921	713	486079	55
6	492308	644	977959	69	514349	713	485651	54
7	492695	644	977918	69	514777	712	485223	53
8	493081	643	977877	69	515204	712	484796	52
9	493466	642	977835	69	515631	711	484369	51
10	493851	642	977794	69	516057	710	483943	50
11	9.494236	641	9.977752	69	9.516484	710	10.483516	49
12	494621	641	977711	69	516910	709	483090	48
13	495005	640	977669	69	517335	709	482665	47
14	495388	639	977628	69	517761	708	482239	46
15	495772	639	977586	69	518185	708	481815	45
16	496154	638	977544	70	518610	707	481390	44
17	496537	637	977503	70	519034	706	480966	43
18	496919	637	977461	70	519458	706	480542	42
19	497301	636	977419	70	519882	705	480118	41
20	497682	636	977377	70	520305	705	479695	40
21	9.498064	635	9.977335	70	9.520728	704	10.479272	39
22	498444	634	977293	70	521151	703	478849	38
23	498825	634	977251	70	521573	703	478427	37
24	499204	633	977209	70	521995	703	478005	36
25	499584	632	977167	70	522417	702	477583	35
26	499963	632	977125	70	522838	702	477162	34
27	500342	631	977083	70	523259	701	476741	33
28	500721	631	977041	70	523680	701	476320	32
29	501099	630	976999	70	524100	700	475900	31
30	501476	629	976957	70	524520	699	475480	30
31	9.501854	629	9.976914	70	9.524939	699	10.475061	29
32	502231	628	976872	71	525359	698	474641	28
33	502607	628	976830	71	525778	698	474222	27
34	502984	627	976787	71	526197	697	473803	26
35	503360	626	976745	71	526615	697	473385	25
36	503735	626	976702	71	527033	696	472967	24
37	504110	625	976660	71	527451	696	472549	23
38	504485	625	976617	71	527868	695	472132	22
39	504860	624	976574	71	528285	695	471715	21
40	505234	623	976532	71	528702	694	471298	20
41	9.505608	623	9.976489	71	9.529119	693	0.470881	19
42	505981	622	976446	71	529535	693	470465	18
43	506354	622	976404	71	529950	693	470050	17
44	506727	621	976361	71	530366	692	469634	16
45	507099	620	976318	71	530781	691	469219	15
46	507471	620	976275	71	531196	691	468804	14
47	507843	619	976232	72	531611	690	468389	13
48	508214	619	976189	72	532025	690	467975	12
49	508585	618	976146	72	532439	689	467561	11
50	508956	618	976103	72	532853	689	467147	10
51	9.509326	617	9.976060	72	9.533266	688	10.466734	9
52	509696	616	976017	72	533679	688	466321	8
53	510065	616	975974	72	534092	687	465908	7
54	510434	615	975930	72	534504	687	465496	6
55	510803	615	975887	72	534916	686	465084	5
56	511172	614	975844	72	535328	686	464672	4
57	511540	613	975800	72	535739	685	464261	3
58	511907	613	975757	72	536150	685	463850	2
59	512275	612	975714	72	536561	684	463439	1
60	512642	612	975670	72	536972	684	463028	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.512642	612	9.975670	73	9.536972	684	10.463028	60
1	513009	611	975627	73	537382	683	462618	59
2	513375	611	975583	73	537792	683	462208	58
3	513741	610	975539	73	538202	682	461798	57
4	514107	609	975496	73	538611	682	461389	56
5	514472	609	975452	73	539020	681	460980	55
6	514837	608	975408	73	539429	681	460571	54
7	515202	608	975365	73	539837	680	460163	53
8	515566	607	975321	73	540245	680	459755	52
9	515930	607	975277	73	540653	679	459347	51
10	516294	606	975233	73	541061	679	458939	50
11	9.516657	605	9.975189	73	9.541468	678	10.458532	49
12	517020	605	975145	73	541875	678	458125	48
13	517382	604	975101	73	542281	677	457719	47
14	517745	604	975057	73	542688	677	457312	46
15	518107	603	975013	73	543094	676	456906	45
16	518468	603	974969	74	543499	676	456501	44
17	518829	602	974925	74	543905	675	456095	43
18	519190	601	974880	74	544310	675	455690	42
19	519551	601	974836	74	544715	674	455285	41
20	519911	600	974792	74	545119	674	454881	40
21	9.520271	600	9.974748	74	9.545524	673	10.454476	39
22	520631	599	974703	74	545928	673	454072	38
23	520990	599	974659	74	546331	672	453669	37
24	521349	598	974614	74	546735	672	453265	36
25	521707	598	974570	74	547138	671	452862	35
26	522066	597	974525	74	547540	671	452460	34
27	522424	596	974481	74	547943	670	452057	33
28	522781	596	974436	74	548345	670	451655	32
29	523138	595	974391	74	548747	669	451253	31
30	523495	595	974347	75	549149	669	450851	30
31	9.523852	594	9.974302	75	9.549550	668	10.450450	29
32	524208	594	974257	75	549951	668	450049	28
33	524564	593	974212	75	550352	667	449648	27
34	524920	593	974167	75	550752	667	449248	26
35	525275	592	974122	75	551152	666	448848	25
36	525630	591	974077	75	551552	666	448448	24
37	525984	591	974032	75	551952	665	448048	23
38	526339	590	973987	75	552351	665	447649	22
39	526693	590	973942	75	552750	665	447250	21
40	527046	589	973897	75	553149	664	446851	20
41	9.527400	589	9.973852	75	9.553548	664	10.446452	19
42	527753	588	973807	75	553946	663	446054	18
43	528105	588	973761	75	554344	663	445656	17
44	528458	587	973716	76	554741	662	445259	16
45	528810	587	973671	76	555139	662	444861	15
46	529161	586	973625	76	555536	661	444464	14
47	529513	586	973580	76	555933	661	444067	13
48	529864	585	973535	76	556329	660	443671	12
49	530215	585	973489	76	556725	660	443275	11
50	530565	584	973444	76	557121	659	442879	10
51	9.530915	584	9.973398	76	9.557517	659	10.442483	9
52	531265	583	973352	76	557913	659	442087	8
53	531614	582	973307	76	558308	658	441692	7
54	531963	582	973261	76	558702	658	441298	6
55	532312	581	973215	76	559097	657	440903	5
56	532661	581	973169	76	559491	657	440509	4
57	533009	580	973124	76	559885	656	440115	3
58	533357	580	973078	76	560279	656	439721	2
59	533704	579	973032	77	560673	655	439327	1
60	534052	578	972986	77	561066	655	438934	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.534052	578	9.972986	77	9.561066	655	10.438934	60
1	534399	577	972940	77	561459	654	438541	59
2	534745	577	972894	77	561851	654	438149	58
3	535092	577	972848	77	562244	653	437756	57
4	535438	576	972802	77	562636	653	437364	56
5	535783	576	972755	77	563028	653	436972	55
6	536129	575	972709	77	563419	652	436581	54
7	536474	574	972663	77	563811	652	436189	53
8	536818	574	972617	77	564202	651	435798	52
9	537163	573	972570	77	564592	651	435408	51
10	537507	573	972524	77	564983	650	435017	50
11	9.537851	572	9.972478	77	9.565373	650	10.434627	49
12	538194	572	972431	78	565763	649	434237	48
13	538538	571	972385	78	566153	649	433347	47
14	538880	571	972338	78	566542	649	433458	46
15	539223	570	972291	78	566932	648	433068	45
16	539565	570	972245	78	567320	648	432680	44
17	539907	569	972198	78	567709	647	432291	43
18	540249	569	972151	78	568098	647	431902	42
19	540590	568	972105	79	568486	646	431514	41
20	540931	568	972058	78	568873	646	431127	40
21	9.541272	567	9.972011	78	9.569261	645	10.430739	39
22	541613	567	971964	78	569648	645	430352	38
23	541953	566	971917	78	570035	645	429965	37
24	542293	566	971870	78	570422	644	429578	36
25	542632	565	971823	78	570809	644	429191	35
26	542971	565	971776	78	571195	643	428805	34
27	543310	564	971729	79	571581	643	428419	33
28	543649	564	971682	79	571967	642	428033	32
29	543987	563	971635	79	572352	642	427648	31
30	544325	563	971588	79	572738	642	427262	30
31	9.544663	562	9.971540	79	9.573123	641	10.426877	29
32	545000	562	971493	79	573507	641	426493	28
33	545338	561	971446	79	573892	640	426108	27
34	545674	561	971398	79	574276	640	425724	26
35	546011	560	971351	79	574660	639	425340	25
36	546347	560	971303	79	575044	639	424956	24
37	546683	559	971256	79	575427	639	424573	23
38	547019	559	971208	79	575810	638	424190	22
39	547354	558	971161	79	576193	638	423307	21
40	547689	558	971113	79	576576	637	423424	20
41	9.548024	557	9.971066	80	9.576958	637	10.423041	19
42	548359	557	971018	80	577341	636	422659	18
43	548693	556	970970	80	577723	636	422277	17
44	549027	556	970922	80	578104	636	421896	16
45	549360	555	970874	80	578486	635	421514	15
46	549693	555	970827	80	578867	635	421133	14
47	550026	554	970779	80	579248	634	420752	13
48	550359	554	970731	80	579629	634	420371	12
49	550692	553	970683	80	580009	634	419991	11
50	551024	553	970635	80	580389	633	419611	10
51	9.551356	552	9.970586	80	9.580769	633	10.419231	9
52	551687	552	970538	80	581149	632	418851	8
53	552018	552	970490	80	581528	632	418472	7
54	552349	551	970442	80	581907	632	418093	6
55	552680	551	970394	80	582286	631	417714	5
56	553010	550	970345	81	582665	631	417335	4
57	553341	550	970297	81	583043	630	416957	3
58	553670	549	970249	81	583422	630	416578	2
59	554000	549	970200	81	583800	629	416200	1
60	554329	548	970152	81	584177	629	415823	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.554329	548	9.970152	81	9.584177	629	10.415823	60
1	554658	548	970103	81	584555	629	415445	59
2	554987	547	970055	81	584932	628	415068	58
3	555315	547	970006	81	585309	628	414691	57
4	555643	546	969957	81	585686	627	414314	56
5	555971	546	969909	81	586062	627	413938	55
6	556299	545	969860	81	586439	627	413561	54
7	556626	545	969811	81	586815	626	413185	53
8	556953	544	969762	81	587190	626	412810	52
9	557280	544	969714	81	587566	625	412434	51
10	557606	543	969665	81	587941	625	412059	50
11	9.557932	543	9.969616	82	9.588316	625	10.411684	49
12	558258	543	969567	82	588691	624	411309	48
13	558583	542	969518	82	589066	624	410934	47
14	558909	542	969469	82	589440	623	410560	46
15	559234	541	969420	82	589814	623	410186	45
16	559558	541	969370	82	590188	623	409812	44
17	559883	540	969321	82	590562	622	409438	43
18	560207	540	969272	82	590935	622	409065	42
19	560531	539	969223	82	591308	622	408692	41
20	560855	539	969173	82	591681	621	408319	40
21	9.561178	538	9.969124	82	9.592054	621	10.407946	39
22	561501	538	969075	82	592426	620	407574	38
23	561824	537	969025	82	592798	620	407202	37
24	562146	537	968976	82	593170	619	406829	36
25	562468	536	968926	83	593542	619	406458	35
26	562790	536	968877	83	593914	618	406086	34
27	563112	536	968827	83	594285	618	405715	33
28	563433	535	968777	83	594656	618	405344	32
29	563755	535	968728	83	595027	617	404973	31
30	564075	534	968678	83	595398	617	404602	30
31	9.564396	534	9.968628	83	9.595768	617	10.404232	29
32	564716	533	968578	83	596138	616	403862	28
33	565036	533	968528	83	596508	616	403492	27
34	565356	532	968479	83	596878	616	403122	26
35	565676	532	968429	83	597247	615	402753	25
36	565995	531	968379	83	597616	615	402384	24
37	566314	531	968329	83	597985	615	402015	23
38	566632	531	968278	83	598354	614	401646	22
39	566951	530	968228	84	598722	614	401278	21
40	567269	530	968178	84	599091	613	400909	20
41	9.567587	529	9.968128	84	9.599459	613	10.400541	19
42	567904	529	968078	84	599827	613	400173	18
43	568222	528	968027	84	600194	612	399806	17
44	568539	528	967977	84	600562	612	399438	16
45	568856	528	967927	84	600929	611	399071	15
46	569172	527	967876	84	601296	611	398704	14
47	569488	527	967826	84	601662	611	398338	13
48	569804	526	967775	84	602029	610	397971	12
49	570120	526	967725	84	602395	610	397605	11
50	570435	525	967674	84	602761	610	397239	10
51	9.570751	525	9.967624	84	9.603127	609	10.396873	9
52	571066	524	967573	84	603493	609	396507	8
53	571380	524	967522	85	603858	609	396142	7
54	571695	523	967471	85	604223	608	395777	6
55	572009	523	967421	85	604588	608	395412	5
56	572323	523	967370	85	604953	607	395047	4
57	572636	522	967319	85	605317	607	394683	3
58	572950	522	967268	85	605682	607	394318	2
59	573263	521	967217	85	606046	606	393954	1
60	573575	521	967166	85	606410	606	393590	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.573575	521	9.967166	85	9.606410	606	10.393590	60
1	573888	520	967115	85	606773	606	393227	59
2	574200	520	967064	85	607137	605	392863	58
3	574512	519	967013	85	607500	605	392500	57
4	574824	519	966961	85	607863	604	392137	56
5	575136	519	966910	85	608225	604	391775	55
6	575447	518	966859	85	608588	604	391412	54
7	575758	518	966808	85	608950	603	391050	53
8	576069	517	966756	86	609312	603	390688	52
9	576379	517	966705	86	609674	603	390326	51
10	576689	516	966653	86	610036	602	389964	50
11	9.576999	516	9.966602	86	9.610397	602	10.389603	49
12	577309	516	966550	86	610759	602	389241	48
13	577618	515	966499	86	611120	601	388880	47
14	577927	515	966447	86	611480	601	388520	46
15	578236	514	966395	86	611841	601	388159	45
16	578545	514	966344	86	612201	600	387799	44
17	578853	513	966292	86	612561	600	387439	43
18	579162	513	966240	86	612921	600	387079	42
19	579470	513	966188	86	613281	599	386719	41
20	579777	512	966136	86	613641	599	386359	40
21	9.580085	512	9.966085	87	9.614000	598	10.386000	39
22	580392	511	966033	87	614359	598	385641	38
23	580699	511	965981	87	614718	598	385282	37
24	581005	511	965928	87	615077	597	384923	36
25	581312	510	965876	87	615435	597	384565	35
26	581618	510	965824	87	615793	597	384207	34
27	581924	509	965772	87	616151	596	383849	33
28	582229	509	965720	87	616509	596	383491	32
29	582535	509	965668	87	616867	596	383133	31
30	582840	508	965615	87	617224	595	382776	30
31	9.583145	508	9.965563	87	9.617582	595	10.382418	29
32	583449	507	965511	87	617939	595	382061	28
33	583754	507	965458	87	618295	594	381705	27
34	584058	506	965406	87	618652	594	381348	26
35	584361	506	965353	88	619008	594	380992	25
36	584665	506	965301	88	619364	593	380636	24
37	584968	505	965248	88	619721	593	380279	23
38	585272	505	965195	88	620076	593	379924	22
39	585574	504	965143	88	620432	592	379568	21
40	585877	504	965090	88	620787	592	379213	20
41	9.586179	503	9.965037	88	9.621142	592	10.378858	19
42	586482	503	964984	88	621497	591	378503	18
43	586783	503	964931	88	621852	591	378148	17
44	587085	502	964879	88	622207	590	377793	16
45	587386	502	964826	88	622561	590	377439	15
46	587688	501	964773	88	622915	590	377085	14
47	587989	501	964719	88	623269	589	376731	13
48	588289	501	964666	89	623623	589	376377	12
49	588590	500	964613	89	623976	589	376024	11
50	588890	500	964560	89	624330	588	375670	10
51	9.589190	499	9.964507	89	9.624683	588	10.375317	9
52	589489	499	964454	89	625036	588	374964	8
53	589789	499	964400	89	625388	587	374612	7
54	590088	498	964347	89	625741	587	374259	6
55	590387	498	964294	89	626093	587	373907	5
56	590686	497	964240	89	626445	586	373555	4
57	590984	497	964187	89	626797	586	373203	3
58	591282	497	964133	89	627149	586	372851	2
59	591580	496	964080	89	627501	585	372499	1
60	591878	496	964026	89	627852	585	372148	0
'	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang	D.	Cotang.	
0	9.591878	496	9.964026	89	9.627852	585	10.372148	60
1	592176	495	963972	89	628203	585	371797	59
2	592473	495	963919	89	628554	585	371446	58
3	592770	495	963865	90	628905	584	371095	57
4	593067	494	963811	90	629255	584	370745	56
5	593363	494	963757	90	629606	583	370394	55
6	593659	493	963704	90	629956	588	370044	54
7	593955	493	963650	90	630306	583	369694	53
8	594251	493	963596	90	630656	583	369344	52
9	594547	492	963542	90	631005	582	368995	51
10	594842	492	963488	90	631355	582	368645	50
11	9.595137	491	9.963434	90	9.631704	582	10.368296	49
12	595432	491	963379	90	632053	581	367947	48
13	595727	491	963325	90	632401	581	367599	47
14	596021	490	963271	90	632750	581	367250	46
15	596315	490	963217	90	633098	580	366902	45
16	596609	489	963163	90	633447	580	366553	44
17	596903	489	963108	91	633795	580	366205	43
18	597196	489	963054	91	634143	579	365857	42
19	597490	488	962999	91	634490	579	365510	41
20	597783	488	962945	91	634838	579	365162	40
21	9.598075	487	9.962890	91	9.635185	578	10.364815	39
22	598368	487	962836	91	635532	578	364468	38
23	598660	487	962781	91	635879	578	364121	37
24	598952	486	962727	91	636226	577	363774	36
25	599244	486	962672	91	636572	577	363428	35
26	599536	485	962617	91	636919	577	363081	34
27	599827	485	962562	91	637265	577	362735	33
28	600118	485	962508	91	637611	576	362389	32
29	600409	484	962453	91	637956	576	362044	31
30	600700	484	962398	92	638302	576	361698	30
31	9.600990	484	9.962343	92	9.638647	575	10.361353	29
32	601280	483	962288	92	638992	575	361008	28
33	601570	483	962233	92	639337	575	360663	27
34	601860	482	962178	92	639682	574	360318	26
35	602150	482	962123	92	640027	574	359973	25
36	602439	482	962067	92	640371	574	359629	24
37	602728	481	962012	92	640716	573	359284	23
38	603017	481	961957	92	641060	573	358940	22
39	603305	481	961902	92	641404	573	358596	21
40	603594	480	961846	92	641747	572	358253	20
41	9.603882	480	9.961791	92	9.642091	572	10.357909	19
42	604170	479	961735	92	642434	572	357566	18
43	604457	479	961680	92	642777	572	357223	17
44	604745	479	961624	93	643120	571	356880	16
45	605032	478	961569	93	643463	571	356537	15
46	605319	478	961513	93	643806	571	356194	14
47	605606	478	961458	93	644148	570	355852	13
48	605892	477	961402	93	644490	570	355510	12
49	606179	477	961346	93	644832	570	355168	11
50	606465	476	961290	93	645174	569	354826	10
51	9.606751	476	9.961235	93	9.645516	569	10.354484	9
52	607036	476	961179	93	645857	569	354143	8
53	607322	475	961123	93	646199	569	353801	7
54	607607	475	961067	93	646540	568	353460	6
55	607892	474	961011	93	646881	568	353119	5
56	608177	474	960955	93	647222	568	352778	4
57	608461	474	960899	93	647562	567	352438	3
58	608745	473	960843	94	647903	567	352097	2
59	609029	473	960786	94	648243	567	351757	1
60	609313	473	960730	94	648583	566	351417	0
	Cosine		Sine		Cotang.		Tang.	M

M	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.609313	473	9.960730	94	9.648583	566	10.351417	60
1	609597	472	960674	94	648923	566	351077	59
2	609880	472	960618	94	649263	566	350737	58
3	610164	472	960561	94	649602	566	350398	57
4	610447	471	960505	94	649942	565	350058	56
5	610729	471	960448	94	650281	565	349719	55
6	611012	470	960392	94	650620	565	349380	54
7	611294	470	960335	94	650959	564	349041	53
8	611576	470	960279	94	651297	564	348703	52
9	611858	469	960222	94	651636	564	348364	51
10	612140	469	960165	94	651974	563	348026	50
11	9.612421	469	9.960109	95	9.652312	563	10.347688	49
12	612702	468	960052	95	652650	563	347350	48
13	612983	468	959995	95	652988	563	347012	47
14	613264	467	959938	95	653326	562	346674	46
15	613545	467	959882	95	653663	562	346337	45
16	613825	467	959825	95	654000	562	346000	44
17	614105	466	959768	95	654337	561	345663	43
18	614385	466	959711	95	654674	561	345326	42
19	614665	466	959654	95	655011	561	344989	41
20	614944	465	959596	95	655348	561	344652	40
21	9.615223	465	9.959539	95	9.655684	560	10.344316	39
22	615502	465	959482	95	656020	560	343980	38
23	615781	464	959425	95	656356	560	343644	37
24	616060	464	959368	95	656692	559	343308	36
25	616338	464	959310	96	657028	559	342972	35
26	616616	463	959253	96	657364	559	342636	34
27	616894	463	959195	96	657699	559	342301	33
28	617172	462	959138	96	658034	558	341966	32
29	617450	462	959081	96	658369	558	341631	31
30	617727	462	959023	96	658704	558	341296	30
31	9.618004	461	9.958965	96	9.659039	558	10.340961	29
32	618281	461	958908	96	659373	557	340627	28
33	618558	461	958850	96	659708	557	340292	27
34	618834	460	958792	96	660042	557	339958	26
35	619110	460	958734	96	660376	557	339624	25
36	619386	460	958677	96	660710	556	339290	24
37	619662	459	958619	96	661043	556	338957	23
38	619938	459	958561	96	661377	556	338623	22
39	620213	459	958503	97	661710	555	338290	21
40	620488	458	958445	97	662043	555	337957	20
41	9.620763	458	9.958387	97	9.662376	555	10.337624	19
42	621038	457	958329	97	662709	554	337291	18
43	621313	457	958271	97	663042	554	336958	17
44	621587	457	958213	97	663375	554	336625	16
45	621861	456	958154	97	663707	554	336293	15
46	622135	456	958096	97	664039	553	335961	14
47	622409	456	958038	97	664371	553	335629	13
48	622682	455	957979	97	664703	553	335297	12
49	622956	455	957921	97	665035	553	334965	11
50	623229	455	957863	97	665366	552	334634	10
51	9.623502	454	9.957804	97	9.665697	552	10.334303	9
52	623774	454	957746	98	666029	552	333971	8
53	624047	454	957687	98	666360	551	333640	7
54	624319	453	957628	98	666691	551	333309	6
55	624591	453	957570	98	667021	551	332979	5
56	624863	453	957511	98	667352	551	332648	4
57	625135	452	957452	98	667682	550	332318	3
58	625406	452	957393	98	668013	550	331987	2
59	625677	452	957335	98	668343	550	331657	1
60	625948	451	957276	98	668672	550	331328	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.625948	451	9.957276	98	9.668673	550	10.331327	60
1	626219	451	957217	98	669002	549	330998	[illegible]
2	626490	451	957158	98	669332	549	330668	58
3	626760	450	957099	98	669661	549	330339	57
4	627030	450	957040	98	669991	548	330009	56
5	627300	450	956981	98	670320	548	329680	55
6	627570	449	956921	99	670649	548	329351	54
7	627840	449	956862	99	670977	548	329023	53
8	628109	449	956803	99	671306	547	328694	52
9	628378	448	956744	99	671634	547	328366	51
10	628647	448	956684	99	671963	547	328037	50
11	9.628916	447	9.956625	[illegible]	9.672291	[illegible]	10.327709	49
12	629185	447	956566	99	672619	[illegible]	327381	48
13	629453	447	[illegible]	99	672947	[illegible]	327053	47
14	629721	446	[illegible]	[illegible]	673274	[illegible]	326726	46
15	629989	446	[illegible]	[illegible]	673602	546	326398	45
16	630257	446	[illegible]	[illegible]	673929	545	326071	44
17	630524	445	[illegible]	[illegible]	674257	545	325743	43
18	[illegible]	445	[illegible]	[illegible]	674584	545	325416	42
19	[illegible]	445	[illegible]	100	674910	544	325090	41
20	631326	445	[illegible]	100	675237	544	324763	40
21	9.631593	444	[illegible]	100	9.675564	544	10.324436	39
22	631859	444	955969	100	675890	544	324110	38
23	632125	444	955909	100	676216	543	323784	37
24	632392	443	955849	100	676543	543	323457	36
25	632658	443	955789	100	676869	543	323131	25
26	632923	443	955729	100	677194	543	322806	34
27	633189	442	955669	100	677520	542	322480	33
28	633454	442	955609	100	677846	542	322154	32
29	633719	442	955548	100	678171	542	321829	31
30	633984	441	955488	100	678496	542	321504	30
31	9.634249	441	9.955428	101	9.678821	541	10.321179	29
32	634514	440	955368	101	679146	541	320854	28
33	634778	440	955307	101	679471	541	320529	27
34	635042	440	955247	101	679795	541	320205	26
35	635306	439	955186	101	680120	540	319880	25
36	635570	439	955126	101	680444	540	319556	24
37	635834	439	955065	101	680768	540	319232	23
38	636097	438	955005	101	681092	540	318908	22
39	636360	438	954944	101	681416	539	318584	21
40	636623	438	954883	101	681740	[illegible]	318260	20
41	9.636886	437	9.954823	101	[illegible]	539	10.317937	19
42	637148	437	954762	101	[illegible]	539	317613	18
43	637411	437	954701	101	682710	538	317290	17
44	637673	437	954640	101	683033	538	316967	16
45	637935	436	954579	101	683356	538	316644	15
46	638197	436	954518	102	683679	538	316321	14
47	638458	436	954457	102	684001	537	315999	13
48	638720	435	954396	102	684324	537	315676	12
49	638981	435	954335	102	684646	537	315354	11
50	639242	435	954274	102	684968	537	315032	10
51	9.639503	434	9.954213	102	9.685290	536	10.314710	9
52	639764	434	954152	102	685612	536	314388	8
53	640024	434	954090	102	685934	536	314066	7
54	640284	433	954029	102	686255	536	313745	6
55	640544	433	953968	102	686577	535	313423	5
56	640804	433	953906	102	686898	535	313102	4
57	641064	432	953845	102	687219	535	312781	3
58	641324	432	953783	102	687540	535	312460	2
59	641584	432	953722	103	687861	534	312139	1
60	641842	431	953660	103	688182	534	311818	0
	Cosine		Sine		Cotang.		Tang.	M.

64 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.641842	431	9.953660	103	9.688182	534	10.311818	60
1	642101	431	953599	103	688502	534	311498	59
2	642360	431	953537	103	688823	534	311177	58
3	642618	430	953475	103	689143	533	310857	57
4	642877	430	953413	103	689463	533	310537	56
5	643135	430	953352	103	689783	533	310217	55
6	643393	430	953290	103	690103	533	309897	54
7	643650	429	953228	103	690423	533	309577	53
8	643908	429	953166	103	690742	532	309258	52
9	644165	429	953104	103	691062	532	308938	51
10	644423	428	953042	103	691381	532	308619	50
11	9.644680	428	9.952980	104	9.691700	531	10.308300	49
12	644936	428	952918	104	692019	531	307981	48
13	645193	427	952855	104	692338	531	307662	47
14	645450	427	952793	104	692656	531	307344	46
15	645706	427	952731	104	692975	531	307025	45
16	645962	426	952669	104	693293	530	306707	44
17	646218	426	952606	104	693612	530	306388	43
18	646474	426	952544	104	693930	530	306070	42
19	646729	425	952481	104	694248	530	305752	41
20	646984	425	952419	104	694566	529	305434	40
21	9.647240	425	9.952356	104	9.694883	529	10.305117	39
22	647494	424	952294	104	695201	529	304799	38
23	647749	424	952231	104	695518	529	304482	37
24	648004	424	952168	105	695836	529	304164	36
25	648258	424	952106	105	696153	528	303847	35
26	648512	428	952043	105	696470	528	303530	34
27	648766	423	951980	105	696787	528	303213	33
28	649020	423	951917	105	697103	528	302897	32
29	649274	422	951854	105	697420	527	302580	31
30	649527	422	951791	105	697736	527	302264	30
31	9.649781	422	9.951728	105	9.698053	527	10.301947	29
32	650034	422	951665	105	698369	527	301631	28
33	650287	421	951602	105	698685	526	301315	27
34	650539	421	951539	105	699001	526	300999	26
35	650792	421	951476	105	699316	526	300684	25
36	651044	420	951412	105	699632	526	300368	24
37	651297	420	951349	106	699947	526	300053	23
38	651549	420	951286	106	700263	525	299737	22
39	651800	419	951222	106	700578	525	299422	21
40	652052	419	951159	106	700893	525	299107	20
41	9.652304	419	9.951096	106	9.701208	524	10.298792	19
42	652555	418	951032	106	701523	524	298477	18
43	652806	418	950968	106	701837	524	298163	17
44	653057	418	950905	106	702152	524	297848	16
45	653308	418	950841	106	702466	524	297534	15
46	653558	417	950778	106	702780	523	297220	14
47	653808	417	950714	106	703095	523	296905	13
48	654059	417	950650	106	703409	523	296591	12
49	654309	416	950586	106	703723	523	296277	11
50	654558	416	950522	107	704036	522	295964	10
51	9.654808	416	9.950458	107	9.704350	522	10.295650	9
52	655058	416	950394	107	704663	522	295337	8
53	655307	415	950330	107	704977	522	295023	7
54	655556	415	950266	107	705290	522	294710	6
55	655805	415	950202	107	705603	521	294397	5
56	656054	414	950138	107	705916	521	294084	4
57	656302	414	950074	107	706228	521	293772	3
58	656551	414	950010	107	706541	521	293459	2
59	656799	413	949945	107	706854	521	293146	1
60	657047	413	949881	107	707166	520	292834	0
	Cosine		Sine		Cotang.		Tang.	M.

M	Sine	D	Cosine	D.	Tang.	D.	Cotang.	
0	9.657047	413	9.949881	107	9.707166	520	10.292834	60
1	657295	413	949816	107	707478	520	292522	59
2	657542	412	949752	107	707790	520	292210	58
3	657790	412	949688	108	708102	520	291898	57
4	658037	412	949623	108	708414	519	291586	56
5	658284	412	949558	108	708726	519	291274	55
6	658531	411	949494	108	709037	519	290963	54
7	658778	411	949429	108	709349	519	290651	53
8	659025	411	949364	108	709660	519	290340	52
9	659271	410	949300	108	709971	518	290029	51
10	659517	410	949235	108	710282	518	289718	50
11	9.659763	410	9.949170	108	9.710593	518	10.289407	49
12	660009	409	949105	108	710904	518	289096	48
13	660255	409	949040	108	711215	518	288785	47
14	660501	409	948975	108	711525	517	288475	46
15	660746	409	948910	108	711836	517	288164	45
16	660991	408	948845	108	712146	517	287854	44
17	661236	408	948780	109	712456	517	287544	43
18	661481	408	948715	109	712766	516	287234	42
19	661726	407	948650	109	713076	516	286924	41
20	661970	407	948584	109	713386	516	286614	40
21	9.662214	407	9.948519	109	9.713696	516	10.286304	39
22	662459	407	948454	109	714005	516	285995	38
23	662703	406	948388	109	714314	515	285686	37
24	662946	406	948323	109	714624	515	285376	36
25	663190	406	948257	109	714933	515	285067	35
26	663433	405	948192	109	715242	515	284758	34
27	663677	405	948126	109	715551	514	284449	33
28	663920	405	948060	109	715860	514	284140	32
29	664163	405	947995	110	716168	514	283832	31
30	664406	404	947929	110	716477	514	283523	30
31	9.664648	404	9.947863	110	9.716785	514	10.283215	29
32	664891	404	947797	110	717093	513	282907	28
33	665133	403	947731	110	717401	513	282599	27
34	665375	403	947665	110	717709	513	282291	26
35	665617	403	947600	110	718017	513	281983	25
36	665859	402	947533	110	718325	513	281675	24
37	666100	402	947467	110	718633	512	281367	23
38	666342	402	947401	110	718940	512	281060	22
39	666583	402	947335	110	719248	512	280752	21
40	666824	401	947269	110	719555	512	280445	20
41	9.667065	401	9.947203	110	9.719862	512	10.280138	19
42	667305	401	947136	111	720169	511	279831	18
43	667546	401	947070	111	720476	511	279524	17
44	667786	400	947004	111	720783	511	279217	16
45	668027	400	946937	111	721089	511	278911	15
46	668267	400	946871	111	721396	511	278604	14
47	668506	399	946804	111	721702	510	278298	13
48	668746	399	946738	111	722009	510	277991	12
49	668986	399	946671	111	722315	510	277685	11
50	669225	399	946604	111	722621	510	277379	10
51	9.669464	398	9.946538	111	9.722927	510	10.277073	9
52	669703	398	946471	111	723232	509	276768	8
53	669942	398	946404	111	723538	509	276462	7
54	670181	397	946337	111	723844	509	276156	6
55	670419	397	946270	112	724149	509	275851	5
56	670658	397	946203	112	724454	509	275546	4
57	670896	397	946136	112	724759	508	275241	3
58	671134	396	946069	112	725065	508	274935	2
59	671372	396	946002	112	725369	508	274631	1
60	671609	396	945935	112	725674	508	274326	0
	Cosine		Sine		Cotang.		Tang.	M.

62 Degrees.

M.	Sine	D.	Cosine	D	Tang.	D.	Cotang.	
0	9.671609	396	9.945935	112	9.725674	508	10.274326	60
1	671847	395	945868	112	725979	508	274021	59
2	672084	395	945800	112	726284	507	273716	58
3	672321	395	945733	112	726588	507	273412	57
4	672558	395	945666	112	726892	507	273108	56
5	672795	394	945598	112	727197	507	272803	55
6	673032	394	945531	112	727501	507	272499	54
7	673268	394	945464	113	727805	506	272195	53
8	673505	394	945396	113	728109	506	271891	52
9	673741	393	945328	113	728412	506	271588	51
10	673977	393	945261	113	728716	506	271284	50
11	9.674213	393	9.945193	113	9.729020	506	10.270980	49
12	674448	392	945125	113	729323	505	270677	48
13	674684	392	945058	113	729626	505	270374	47
14	674919	392	944990	113	729929	505	270071	46
15	675155	392	944922	113	730233	505	269767	45
16	675390	391	944854	113	730535	505	269465	44
17	675624	391	944786	113	730838	504	269162	43
18	675859	391	944718	113	731141	504	268859	42
19	676094	391	944650	113	731444	504	268556	41
20	676328	390	944582	114	731746	504	268254	40
21	9.676562	390	9.944514	114	9.732048	504	10.267952	39
22	676796	390	944446	114	732351	503	267649	38
23	677030	390	944377	114	732653	503	267347	37
24	677264	389	944309	114	732955	503	267045	36
25	677498	389	944241	114	733257	503	266743	35
26	677731	389	944172	114	733558	503	266442	34
27	677964	388	944104	114	733860	502	266140	33
28	678197	388	944036	114	734162	502	265838	32
29	678430	388	943967	114	734463	502	265537	31
30	678663	388	943899	114	734764	502	265236	30
31	9.678895	387	9.943830	114	9.735066	502	10.264934	29
32	679128	387	943761	114	735367	502	264633	28
33	679360	387	943693	115	735668	501	264332	27
34	679592	387	943624	115	735969	501	264031	26
35	679824	386	943555	115	736269	501	263731	25
36	680056	386	943486	115	736570	501	263430	24
37	680288	386	943417	115	736871	501	263129	23
38	680519	385	943348	115	737171	500	262829	22
39	680750	385	943279	115	737471	500	262529	21
40	680982	385	943210	115	737771	500	262229	20
41	9.681213	385	9.943141	115	9.738071	500	10.261929	19
42	681443	384	943072	115	738371	500	261629	18
43	681674	384	943003	115	738671	499	261329	17
44	681905	384	942934	115	738971	499	261029	16
45	682135	384	942864	115	739271	499	260729	15
46	682365	383	942795	116	739570	499	260430	14
47	682595	383	942726	116	739870	499	260130	13
48	682825	383	942656	116	740169	499	259831	12
49	683055	383	942587	116	740468	498	259532	11
50	683284	382	942517	116	740767	498	259233	10
51	9.683514	382	9.942448	116	9.741066	498	10.258934	9
52	683743	382	942378	116	741365	498	258635	8
53	683972	382	942308	116	741664	498	258336	7
54	684201	381	942239	116	741962	497	258038	6
55	684430	381	942169	116	742261	497	257739	5
56	684658	381	942099	116	742559	497	257441	4
57	684887	380	942029	116	742858	497	257142	3
58	685115	380	941959	116	743156	497	256844	2
59	685343	380	941889	117	743454	497	256546	1
60	685571	380	941819	117	743752	496	256248	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.685571	380	9.941819	117	9.743752	496	10.256248	60
1	685799	379	941749	117	744050	496	255950	59
2	686027	379	941679	117	744348	496	255652	58
3	686254	379	941609	117	744645	496	255355	57
4	686482	379	941539	117	744943	496	255057	56
5	686709	378	941469	117	745240	496	254760	55
6	686936	378	941398	117	745538	495	254462	54
7	687163	378	941328	117	745835	495	254165	53
8	687389	378	941258	117	746132	495	253868	52
9	687616	377	941187	117	746429	495	253571	51
10	687843	377	941117	117	746726	495	253274	50
11	9.688069	377	9.941046	118	9.747023	494	10.252977	49
12	688295	377	940975	118	747319	494	252681	48
13	688521	376	940905	118	747616	494	252384	47
14	688747	376	940834	118	747913	494	252087	46
15	688972	376	940763	118	748209	494	251791	45
16	689198	376	940693	118	748505	493	251495	44
17	689423	375	940622	118	748801	493	251199	43
18	689648	375	940551	118	749097	493	250903	42
19	689873	375	940480	118	749393	493	250607	41
20	690098	375	940409	118	749689	493	250311	40
21	9.690323	374	9.940338	118	9.749985	493	10.250015	39
22	690548	374	940267	118	750281	492	249719	38
23	690772	374	940196	118	750576	492	249424	37
24	690996	374	940125	119	750872	492	249128	36
25	691220	373	940054	119	751167	492	248833	35
26	691444	373	939982	119	751462	492	248538	34
27	691668	373	939911	119	751757	492	248243	33
28	691892	373	939840	119	752052	491	247948	32
29	692115	372	939768	119	752347	491	247653	31
30	692339	372	939697	119	752642	491	247358	30
31	9.692562	372	9.939625	119	9.752937	491	10.247063	29
32	692785	371	939554	119	753231	491	246769	28
33	693008	371	939482	119	753526	491	246474	27
34	693231	371	939410	119	753820	490	246180	26
35	693453	371	939339	119	754115	490	245885	25
36	693676	370	939267	120	754409	490	245591	24
37	693898	370	939195	120	754703	490	245297	23
38	694120	370	939123	120	754997	490	245003	22
39	694342	370	939052	120	755291	490	244709	21
40	694564	369	938980	120	755585	489	244415	20
41	9.694786	369	9.938908	120	9.755878	489	10.244122	19
42	695007	369	938836	120	756172	489	243828	18
43	695229	369	938763	120	756465	489	243535	17
44	695450	368	938691	120	756759	489	243241	16
45	695671	368	938619	120	757052	489	242948	15
46	695892	368	938547	120	757345	488	242655	14
47	696113	368	938475	120	757638	488	242362	13
48	696334	367	938402	121	757931	488	242069	12
49	696554	367	938330	121	758224	488	241776	11
50	696775	367	938258	121	758517	488	241483	10
51	9.696995	367	9.938185	121	9.758810	488	10.241190	9
52	697215	366	938113	121	759102	487	240898	8
53	697435	366	938040	121	759395	487	240605	7
54	697654	366	937967	121	759687	487	240313	6
55	697874	366	937895	121	759979	487	240021	5
56	698094	365	937822	121	760272	487	239728	4
57	698313	365	937749	121	760564	487	239436	3
58	698532	365	937676	121	760856	486	239144	2
59	698751	365	937604	121	761148	486	238852	1
60	698970	364	937531	121	761439	486	238561	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.698970	364	9.937531	121	9.761439	486	10.238561	60
1	699189	364	937458	122	761731	486	238269	59
2	699407	364	937385	122	762023	486	237977	58
3	699626	364	937312	122	762314	486	237686	57
4	699844	363	937238	122	762606	485	237394	56
5	700062	363	937165	122	762897	485	237103	55
6	700280	363	937092	122	763188	485	236812	54
7	700498	363	937019	122	763479	485	236521	53
8	700716	363	936946	122	763770	485	236230	52
9	700933	362	936872	122	764061	485	235939	51
10	701151	362	936799	122	764352	484	235648	50
11	9.701368	362	9.936725	122	9.764643	484	10.235357	49
12	701585	362	936652	123	764933	484	235067	48
13	701802	361	936578	123	765224	484	234776	47
14	702019	361	936505	123	765514	484	234486	46
15	702236	361	936431	123	765805	484	234195	45
16	702452	361	936357	123	766095	484	233905	44
17	702669	360	936284	123	766385	483	233615	43
18	702885	360	936210	123	766675	483	233325	42
19	703101	360	936136	123	766965	483	233035	41
20	703317	360	936062	123	767255	483	232745	40
21	9.703533	359	9.935988	123	9.767545	483	10.232455	39
22	703749	359	935914	123	767834	483	232166	38
23	703964	359	935840	123	768124	482	231876	37
24	704179	359	935766	124	768413	482	231587	36
25	704395	359	935692	124	768703	482	231297	35
26	704610	358	935618	124	768992	482	231008	34
27	704825	358	935543	124	769281	482	230719	33
28	705040	358	935469	124	769570	482	230430	32
29	705254	358	935395	124	769860	481	230140	31
30	705469	357	935320	124	770148	481	229852	30
31	9.705683	357	9.935246	124	9.770437	481	10.229563	29
32	705898	357	935171	124	770726	481	229274	28
33	706112	357	935097	124	771015	481	228985	27
34	706326	356	935022	124	771303	481	228697	26
35	706539	356	934948	124	771592	481	228408	25
36	706753	356	934873	124	771880	480	228120	24
37	706967	356	934798	125	772168	480	227832	23
38	707180	355	934723	125	772457	480	227543	22
39	707393	355	934649	125	772745	480	227255	21
40	707606	355	934574	125	773033	480	226967	20
41	9.707819	355	9.934499	125	9.773321	480	10.226679	19
42	708032	354	934424	125	773608	479	226392	18
43	708245	354	934349	125	773896	479	226104	17
44	708458	354	934274	125	774184	479	225816	16
45	708670	354	934199	125	774471	479	225529	15
46	708882	353	934123	125	774759	479	225241	14
47	709094	353	934048	125	775046	479	224954	13
48	709306	353	933973	125	775333	479	224667	12
49	709518	353	933898	126	775621	478	224379	11
50	709730	353	933822	126	775908	478	224092	10
51	9.709941	352	9.933747	126	9.776195	478	10.223805	9
52	710153	352	933671	126	776482	478	223518	8
53	710364	352	933596	126	776769	478	223231	7
54	710575	352	933520	126	777055	478	222945	6
55	710786	351	933445	126	777342	478	222658	5
56	710997	351	933369	126	777628	477	222372	4
57	711208	351	933293	126	777915	477	222085	3
58	711419	351	933217	126	778201	477	221799	2
59	711629	350	933141	126	778487	477	221512	1
60	711839	350	933066	126	778774	477	221226	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.711839	350	9.933066	126	9.778774	477	10.221226	60
1	712050	350	932990	127	779060	477	220940	59
2	712260	350	932914	127	779346	476	220654	58
3	712469	349	932838	127	779632	476	220368	57
4	712679	349	932762	127	779918	476	220082	56
5	712889	349	932685	127	780203	476	219797	55
6	713098	349	932609	127	780489	476	219511	54
7	713308	349	932533	127	780775	476	219225	53
8	713517	348	932457	127	781060	476	218940	52
9	713726	348	932380	127	781346	475	218654	51
10	713935	348	932304	127	781631	475	218369	50
11	9.714144	348	9.932228	127	9.781916	475	10.218084	49
12	714352	347	932151	127	782201	475	217799	48
13	714561	347	932075	128	782486	475	217514	47
14	714769	347	931998	128	782771	475	217229	46
15	714978	347	931921	128	783056	475	216944	45
16	715186	347	931845	128	783341	475	216659	44
17	715394	346	931768	128	783626	474	216374	43
18	715602	346	931691	128	783910	474	216090	42
19	715809	346	931614	128	784195	474	215805	41
20	716017	346	931537	128	784479	474	215521	40
21	9.716224	345	9.931460	128	9.784764	474	10.215236	39
22	716432	345	931383	128	785048	474	214952	38
23	716639	345	931306	128	785332	473	214668	37
24	716846	345	931229	129	785616	473	214384	36
25	717053	345	931152	129	785900	473	214100	35
26	717259	344	931075	129	786184	473	213816	34
27	717466	344	930998	129	786468	473	213532	33
28	717673	344	930921	129	786752	473	213248	32
29	717879	344	930843	129	787036	473	212964	31
30	718085	343	930766	129	787319	472	212681	30
31	9.718291	343	9.930688	129	9.787603	472	10.212397	29
32	718497	343	930611	129	787886	472	212114	28
33	718703	343	930533	129	788170	472	211830	27
34	718909	343	930456	129	788453	472	211547	26
35	719114	342	930378	129	788736	472	211264	25
36	719320	342	930300	130	789019	472	210981	24
37	719525	342	930223	130	789302	471	210698	23
38	719730	342	930145	130	789585	471	210415	22
39	719935	341	930067	130	789868	471	210132	21
40	720140	341	929989	130	790151	471	209849	20
41	9.720345	341	9.929911	130	9.790433	471	10.209567	19
42	720549	341	929833	130	790716	471	209284	18
43	720754	340	929755	130	790999	471	209001	17
44	720958	340	929677	130	791281	471	208719	16
45	721162	340	929599	130	791563	470	208437	15
46	721366	340	929521	130	791846	470	208154	14
47	721570	340	929442	130	792128	470	207872	13
48	721774	339	929364	131	792410	470	207590	12
49	721978	339	929286	131	792692	470	207308	11
50	722181	339	929207	131	792974	470	207026	10
51	9.722385	339	9.929129	131	9.793256	470	10.206744	9
52	722588	339	929050	131	793538	469	206462	8
53	722791	338	928972	131	793819	469	206181	7
54	722994	338	928893	131	794101	469	205899	6
55	723197	338	928815	131	794383	469	205617	5
56	723400	338	928736	131	794664	469	205336	4
57	723603	337	928657	131	794945	469	205055	3
58	723805	337	928578	131	795227	469	204773	2
59	724007	337	928499	131	795508	468	204492	1
60	724210	337	928420	131	795789	468	204211	0
	Cosine		Sine		Cotang.		Tang.	M.

M	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.724210	337	9.928420	132	9.795789	468	10.204211	60
1	724412	337	928342	132	796070	468	203930	59
2	724614	336	928263	132	796351	468	203649	58
3	724816	336	928183	132	796632	468	203368	57
4	725017	336	928104	132	796913	468	203087	56
5	725219	336	928025	132	797194	468	202806	55
6	725420	335	927946	132	797475	468	202525	54
7	725622	335	927867	132	797755	468	202245	53
8	725823	335	927787	132	798036	467	201964	52
9	726024	335	927708	132	798316	467	201684	51
10	726225	335	927629	132	798596	467	201404	50
11	9.726426	334	9.927549	132	9.798877	467	10.201123	49
12	726626	334	927470	133	799157	467	200843	48
13	726827	334	927390	133	799437	467	200563	47
14	727027	334	927310	133	799717	467	200283	46
15	727228	334	927231	133	799997	466	200003	45
16	727428	333	927151	133	800277	466	199723	44
17	727628	333	927071	133	800557	466	199443	43
18	727828	333	926991	133	800836	466	199164	42
19	728027	333	926911	133	801116	466	198884	41
20	728227	333	926831	133	801396	466	198604	40
21	9.728427	332	9.926751	133	9.801675	466	10.198325	39
22	728626	332	926671	133	801955	466	198045	38
23	728825	332	926591	133	802234	465	197766	37
24	729024	332	926511	134	802513	465	197487	36
25	729223	331	926431	134	802792	465	197208	35
26	729422	331	926351	134	803072	465	196928	34
27	729621	331	926270	134	803351	465	196649	33
28	729820	331	926190	134	803630	465	196370	32
29	730018	330	926110	134	803908	465	196092	31
30	730216	330	926029	134	804187	465	195813	30
31	9.730415	330	9.925949	134	9.804466	464	10.195534	29
32	730613	330	925868	134	804745	464	195255	28
33	730811	330	925788	134	805023	464	194977	27
34	731009	329	925707	134	805302	464	194698	26
35	731206	329	925626	134	805580	464	194420	25
36	731404	329	925545	135	805859	464	194141	24
37	731602	329	925465	135	806137	464	193863	23
38	731799	329	925384	135	806415	463	193585	22
39	731996	328	925303	135	806693	463	193307	21
40	732193	328	925222	135	806971	463	193029	20
41	9.732390	328	9.925141	135	9.807249	463	10.192751	19
42	732587	328	925060	135	807527	463	192473	18
43	732784	328	924979	135	807805	463	192195	17
44	732980	327	924897	135	808083	463	191917	16
45	733177	327	924816	135	808361	463	191639	15
46	733373	327	924735	136	808638	462	191362	14
47	733569	327	924654	136	808916	462	191084	13
48	733765	327	924572	136	809193	462	190807	12
49	733961	326	924491	136	809471	462	190529	11
50	734157	326	924409	136	809748	462	190252	10
51	9.734353	326	9.924328	136	9.810025	462	10.189975	9
52	734549	326	924246	136	810302	462	189698	8
53	734744	325	924164	136	810580	462	189420	7
54	734939	325	924083	136	810857	462	189143	6
55	735135	325	924001	136	811134	461	188866	5
56	735330	325	923919	136	811410	461	188590	4
57	735525	325	923837	136	811687	461	188313	3
58	735719	324	923755	137	811964	461	188036	2
59	735914	324	923673	137	812241	461	187759	1
60	736109	324	923591	137	812517	461	187483	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.736109	324	9.923591	137	9.812517	461	10.187483	60
1	736303	324	923509	137	812794	461	187206	59
2	736498	324	923427	137	813070	461	186930	58
3	736692	323	923345	137	813347	460	186653	57
4	736886	323	923263	137	813623	460	186377	56
5	737080	323	923181	137	813899	460	186101	55
6	737274	323	923098	137	814175	460	185825	54
7	737467	323	923016	137	814452	460	185548	53
8	737661	322	922933	137	814728	460	185272	52
9	737855	322	922851	137	815004	460	184996	51
10	738048	322	922768	138	815279	460	184721	50
11	9.738241	322	9.922686	138	9.815555	459	10.184445	49
12	738434	322	922603	138	815831	459	184169	48
13	738627	321	922520	138	816107	459	183893	47
14	738820	321	922438	138	816382	459	183618	46
15	739013	321	922355	138	816658	459	183342	45
16	739206	321	922272	138	816933	459	183067	44
17	739398	321	922189	138	817209	459	182791	43
18	739590	320	922106	138	817484	459	182516	42
19	739783	320	922023	138	817759	459	182241	41
20	739975	320	921940	138	818035	458	181965	40
21	9.740167	320	9.921857	139	9.818310	458	10.181690	39
22	740359	320	921774	139	818585	458	181415	38
23	740550	319	921691	139	818860	458	181140	37
24	740742	319	921607	139	819135	458	180865	36
25	740934	319	921524	139	819410	458	180590	35
26	741125	319	921441	139	819684	458	180316	34
27	741316	319	921357	139	819959	458	180041	33
28	741508	318	921274	139	820234	458	179766	32
29	741699	318	921190	139	820508	457	179492	31
30	741889	318	921107	139	820783	457	179217	30
31	9.742080	318	9.921023	139	9.821057	457	10.178943	29
32	742271	318	920939	140	821332	457	178668	28
33	742462	317	920856	140	821606	457	178394	27
34	742652	317	920772	140	821880	457	178120	26
35	742842	317	920688	140	822154	457	177846	25
36	743033	317	920604	140	822429	457	177571	24
37	743223	317	920520	140	822703	457	177297	23
38	743413	316	920436	140	822977	456	177023	22
39	743602	316	920352	140	823250	456	176750	21
40	743792	316	920268	140	823524	456	176476	20
41	9.743982	316	9.920184	140	9.823798	456	10.176202	19
42	744171	316	920099	140	824072	456	175928	18
43	744361	315	920015	140	824345	456	175655	17
44	744550	315	919931	141	824619	456	175381	16
45	744739	315	919846	141	824893	456	175107	15
46	744928	315	919762	141	825166	456	174834	14
47	745117	315	919677	141	825439	455	174561	13
48	745306	314	919593	141	825713	455	174287	12
49	745494	314	919508	141	825986	455	174014	11
50	745683	314	919424	141	826259	455	173741	10
51	9.745871	314	9.919339	141	9.826532	455	10.173468	9
52	746059	314	919254	141	826805	455	173195	8
53	746248	313	919169	141	827078	455	172922	7
54	746436	313	919085	141	827351	455	172649	6
55	746624	313	919000	141	827624	455	172376	5
56	746812	313	918915	142	827897	454	172103	4
57	746999	313	918830	142	828170	454	171830	3
58	747187	312	918745	142	828442	454	171558	2
59	747374	312	918659	142	828715	454	171285	1
60	747562	312	918574	142	828987	454	171013	0
	Cosine		Sine		Cotang.		Tang.	M.

19*

Gg

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.747562	312	9.918574	142	9.828987	454	10.171013	60
1	747749	312	918489	142	829260	454	170740	59
2	747936	312	918404	142	829532	454	170468	58
3	748123	311	918318	142	829805	454	170195	57
4	748310	311	918233	142	830077	454	169923	56
5	748497	311	918147	142	830349	453	169651	55
6	748683	311	918062	142	830621	453	169379	54
7	748870	311	917976	143	830893	453	169107	53
8	749056	310	917891	143	831165	453	168835	52
9	749243	310	917805	143	831437	453	168563	51
10	749429	310	917719	143	831709	453	168291	50
11	9.749615	310	9.917634	143	9.831981	453	10.168019	49
12	749801	310	917548	143	832253	453	167747	48
13	749987	309	917462	143	832525	453	167475	47
14	750172	309	917376	143	832796	453	167204	46
15	750358	309	917290	143	833068	452	166932	45
16	750543	309	917204	143	833339	452	166661	44
17	750729	309	917118	144	833611	452	166389	43
18	750914	308	917032	144	833882	452	166118	42
19	751099	308	916946	144	834154	452	165846	41
20	751284	308	916859	144	834425	452	165575	40
21	9.751469	308	9.916773	144	9.834696	452	10.165304	39
22	751654	308	916687	144	834967	452	165033	38
23	751839	308	916600	144	835238	452	164762	37
24	752023	307	916514	144	835509	452	164491	36
25	752208	307	916427	144	835780	451	164220	35
26	752392	307	916341	144	836051	451	163949	34
27	752576	307	916254	144	836322	451	163678	33
28	752760	307	916167	145	836593	451	163407	32
29	752944	306	916081	145	836864	451	163136	31
30	753128	306	915994	145	837134	451	162866	30
31	9.753312	306	9.915907	145	9.837405	451	10.162595	29
32	753495	306	915820	145	837675	451	162325	28
33	753679	306	915733	145	837946	451	162054	27
34	753862	305	915646	145	838216	451	161784	26
35	754046	305	915559	145	838487	450	161513	25
36	754229	305	915472	145	838757	450	161243	24
37	754412	305	915385	145	839027	450	160973	23
38	754595	305	915297	145	839297	450	160703	22
39	754778	304	915210	145	839568	450	160432	21
40	754960	304	915123	146	839838	450	160162	20
41	9.755143	304	9.915035	146	9.840108	450	10.159892	19
42	755326	304	914948	146	840378	450	159622	18
43	755508	304	914860	146	840647	450	159353	17
44	755690	304	914773	146	840917	449	159083	16
45	755872	303	914685	146	841187	449	158813	15
46	756054	303	914598	146	841457	449	158543	14
47	756236	303	914510	146	841726	449	158274	13
48	756418	303	914422	146	841996	449	158004	12
49	756600	303	914334	146	842266	449	157734	11
50	756782	302	914246	147	842535	449	157465	10
51	9.756963	302	9.914158	147	9.842805	449	10.157195	9
52	757144	302	914070	147	843074	449	156926	8
53	757326	302	913982	147	843343	449	156657	7
54	757507	302	913894	147	843612	449	156388	6
55	757688	301	913806	147	843882	448	156118	5
56	757869	301	913718	147	844151	448	155849	4
57	758050	301	913630	147	844420	448	155580	3
58	758230	301	913541	147	844689	448	155311	2
59	758411	301	913453	147	844958	448	155042	1
60	758591	301	913365	147	845227	448	154773	0
	Cosine		Sine		Cotang.		Tang.	M

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.758591	301	9.913365	147	9.845227	448	10.154773	60
1	758772	300	913276	147	845496	448	154504	59
2	758952	300	913187	148	845764	448	154236	58
3	759132	300	913099	148	846033	448	153967	57
4	759312	300	913010	148	846302	448	153698	56
5	759492	300	912922	148	846570	447	153430	55
6	759672	299	912833	148	846839	447	153161	54
7	759852	299	912744	148	847107	447	152893	53
8	760031	299	912655	148	847376	447	152624	52
9	760211	299	912566	148	847644	447	152356	51
10	760390	299	912477	148	847913	447	152087	50
11	9.760569	298	9.912388	148	9.848181	447	10.151819	49
12	760748	298	912299	149	848449	447	151551	48
13	760927	298	912210	149	848717	447	151283	47
14	761106	298	912121	149	848986	447	151014	46
15	761285	298	912031	149	849254	447	150746	45
16	761464	298	911942	149	849522	447	150478	44
17	761642	297	911853	149	849790	446	150210	43
18	761821	297	911763	149	850058	446	149942	42
19	761999	297	911674	149	850325	446	149675	41
20	762177	297	911584	149	850593	446	149407	40
21	9.762356	297	9.911495	149	9.850861	446	10.149139	39
22	762534	296	911405	149	851129	446	148871	38
23	762712	296	911315	150	851396	446	148604	37
24	762889	296	911226	150	851664	446	148336	36
25	763067	296	911136	150	851931	446	148069	35
26	763245	296	911046	150	852199	446	147801	34
27	763422	296	910956	150	852466	446	147534	33
28	763600	295	910866	150	852733	445	147267	32
29	763777	295	910776	150	853001	445	146999	31
30	763954	295	910686	150	853268	445	146732	30
31	9.764131	295	9.910596	150	9.853535	445	10.146465	29
32	764308	295	910506	150	853802	445	146198	28
33	764485	294	910415	150	854069	445	145931	27
34	764662	294	910325	151	854336	445	145664	26
35	764838	294	910235	151	854603	445	145397	25
36	765015	294	910144	151	854870	445	145130	24
37	765191	294	910054	151	855137	445	144863	23
38	765367	294	909963	151	855404	445	144596	22
39	765544	293	909873	151	855671	444	144329	21
40	765720	293	909782	151	855938	444	144062	20
41	9.765896	293	9.909691	151	9.856204	444	10.143796	19
42	766072	293	909601	151	856471	444	143529	18
43	766247	293	909510	151	856737	444	143263	17
44	766423	293	909419	151	857004	444	142996	16
45	766598	292	909328	152	857270	444	142730	15
46	766774	292	909237	152	857537	444	142463	14
47	766949	292	909146	152	857803	444	142197	13
48	767124	292	909055	152	858069	444	141931	12
49	767300	292	908964	152	858336	444	141664	11
50	767475	291	908873	152	858602	443	141398	10
51	9.767649	291	9.908781	152	9.858868	443	10.141132	9
52	767824	291	908690	152	859134	443	140866	8
53	767999	291	908599	152	859400	443	140600	7
54	768173	291	908507	152	859666	443	140334	6
55	768348	290	908416	153	859932	443	140068	5
56	768522	290	908324	153	860198	443	139802	4
57	768697	290	908233	153	860464	443	139536	3
58	768871	290	908141	153	860730	443	139270	2
59	769045	290	908049	153	860995	443	139005	1
60	769219	290	907958	153	861261	443	138739	0
	Cosine		Sine		Cotang.		Tang.	M.

54 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.769219	290	9.907958	153	9.861261	443	10.138739	60
1	769393	289	907866	153	861527	443	138473	59
2	769566	289	907774	153	861792	442	138208	58
3	769740	289	907682	153	862058	442	137942	57
4	769913	289	907590	153	862323	442	137677	56
5	770087	289	907498	153	862589	442	137411	55
6	770260	288	907406	153	862854	442	137146	54
7	770433	288	907314	154	863119	442	136881	53
8	770606	288	907222	154	863385	442	136615	52
9	770779	288	907129	154	863650	442	136350	51
10	770952	288	907037	154	863915	442	136085	50
11	9.771125	288	9.906945	154	9.864180	442	10.135820	49
12	771298	287	906852	154	864445	442	135555	48
13	771470	287	906760	154	864710	442	135290	47
14	771643	287	906667	154	864975	441	135025	46
15	771815	287	906575	154	865240	441	134760	45
16	771987	287	906482	154	865505	441	134495	44
17	772159	287	906389	155	865770	441	134230	43
18	772331	286	906296	155	866035	441	133965	42
19	772503	286	906204	155	866300	441	133700	41
20	772675	286	906111	155	866564	441	133436	40
21	9.772847	286	9.906018	155	9.866829	441	10.133171	39
22	773018	286	905925	155	867094	441	132906	38
23	773190	286	905832	155	867358	441	132642	37
24	773361	285	905739	155	867623	441	132377	36
25	773533	285	905645	155	867887	441	132113	35
26	773704	285	905552	155	868152	440	131848	34
27	773875	285	905459	155	868416	440	131584	33
28	774046	285	905366	156	868680	440	131320	32
29	774217	285	905272	156	868945	440	131055	31
30	774388	284	905179	156	869209	440	130791	30
31	9.774558	284	9.905085	156	9.869473	440	10.130527	29
32	774729	284	904992	156	869737	440	130263	28
33	774899	284	904898	156	870001	440	129999	27
34	775070	284	904804	156	870265	440	129735	26
35	775240	284	904711	156	870529	440	129471	25
36	775410	283	904617	156	870793	440	129207	24
37	775580	283	904523	156	871057	440	128943	23
38	775750	283	904429	157	871321	440	128679	22
39	775920	283	904335	157	871585	440	128415	21
40	776090	283	904241	157	871849	439	128151	20
41	9.776259	283	9.904147	157	9.872112	439	10.127888	19
42	776429	282	904053	157	872376	439	127624	18
43	776598	282	903959	157	872640	439	127360	17
44	776768	282	903864	157	872903	439	127097	16
45	776937	282	903770	157	873167	439	126833	15
46	777106	282	903676	157	873430	439	126570	14
47	777275	281	903581	157	873694	439	126306	13
48	777444	281	903487	157	873957	439	126043	12
49	777613	281	903392	158	874220	439	125780	11
50	777781	281	903298	158	874484	439	125516	10
51	9.777950	281	9.903203	158	9.874747	439	10.125253	9
52	778119	281	903108	158	875010	439	124990	8
53	778287	280	903014	158	875273	438	124727	7
54	778455	280	902919	158	875536	438	124464	6
55	778624	280	902824	158	875800	438	124200	5
56	778792	280	902729	158	876063	438	123937	4
57	778960	280	902634	158	876326	438	123674	3
58	779128	280	902539	159	876589	438	123411	2
59	779295	279	902444	159	876851	438	123149	1
60	779463	279	902349	159	877114	438	122886	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.779463	279	9.902349	159	9.877114	438	10.122886	60
1	779631	279	902253	159	877377	438	122623	59
2	779798	279	902158	159	877640	438	122360	58
3	779966	279	902063	159	877903	438	122097	57
4	780133	279	901967	159	878165	438	121835	56
5	780300	278	901872	159	878428	438	121572	55
6	780467	278	901776	159	878691	438	121309	54
7	780634	278	901681	159	878953	437	121047	53
8	780801	278	901585	159	879216	437	120784	52
9	780968	278	901490	159	879478	437	120522	51
10	781134	278	901394	160	879741	437	120259	50
11	9.781301	277	9.901298	160	9.880003	437	10.119997	49
12	781468	277	901202	160	880265	437	119735	48
13	781634	277	901106	160	880528	437	119472	47
14	781800	277	901010	160	880790	437	119210	46
15	781966	277	900914	160	881052	437	118948	45
16	782132	277	900818	160	881314	437	118686	44
17	782298	276	900722	160	881576	437	118424	43
18	782464	276	900626	160	881839	437	118161	42
19	782630	276	900529	160	882101	437	117899	41
20	782796	276	900433	161	882363	436	117637	40
21	9.782961	276	9.900337	161	9.882625	436	10.117375	39
22	783127	276	900240	161	882887	436	117113	38
23	783292	275	900144	161	883148	436	116852	37
24	783458	275	900047	161	883410	436	116590	36
25	783623	275	899951	161	883672	436	116328	35
26	783788	275	899854	161	883934	436	116066	34
27	783953	275	899757	161	884196	436	115804	33
28	784118	275	899660	161	884457	436	115543	32
29	784282	274	899564	161	884719	436	115281	31
30	784447	274	899467	162	884980	436	115020	30
31	9.784612	274	9.899370	162	9.885242	436	10.114758	29
32	784776	274	899273	162	885503	436	114497	28
33	784941	274	899176	162	885765	436	114235	27
34	785105	274	899078	162	886026	436	113974	26
35	785269	273	898981	162	886288	436	113712	25
36	785433	273	898884	162	886549	435	113451	24
37	785597	273	898787	162	886810	435	113190	23
38	785761	273	898689	162	887072	435	112928	22
39	785925	273	898592	162	887333	435	112667	21
40	786089	273	898494	163	887594	435	112406	20
41	9.786252	272	9.898397	163	9.887855	435	10.112145	19
42	786416	272	898299	163	888116	435	111884	18
43	786579	272	898202	163	888377	435	111623	17
44	786742	272	898104	163	888639	435	111361	16
45	786906	272	898006	163	888900	435	111100	15
46	787069	272	897908	163	889160	435	110840	14
47	787232	271	897810	163	889421	435	110579	13
48	787395	271	897712	163	889682	435	110318	12
49	787557	271	897614	163	889943	435	110057	11
50	787720	271	897516	163	890204	434	109796	10
51	9.787883	271	9.897418	164	9.890465	434	10.109535	9
52	788045	271	897320	164	890725	434	109275	8
53	788208	271	897222	164	890986	434	109014	7
54	788370	270	897123	164	891247	434	108753	6
55	788532	270	897025	164	891507	434	108493	5
56	788694	270	896926	164	891768	434	108232	4
57	788856	270	896828	164	892028	434	107972	3
58	789018	270	896729	164	892289	434	107711	2
59	789180	270	896631	164	892549	434	107451	1
60	789342	269	896532	164	892810	434	107190	0
	Cosine		Sine		Cotang.		Tang.	M.

52 Degrees

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.789342	269	9.896532	164	9.892810	434	10.107190	60
1	789504	269	896433	165	893070	434	106930	59
2	789665	269	896335	165	893331	431	106669	58
3	789827	269	896236	165	893591	431	106409	57
4	789988	269	896137	165	893851	434	106149	56
5	790149	269	896038	165	894111	434	105839	55
6	790310	268	895939	165	894371	434	105629	54
7	790471	268	895840	165	894632	433	105368	53
8	790632	268	895741	165	894892	433	105108	52
9	790793	268	895641	165	895152	433	104848	51
10	790954	268	895542	165	895412	433	104588	50
11	9.791115	268	9.895443	166	9.895672	433	10.104328	49
12	791275	267	895343	166	895932	433	104068	48
13	791436	267	895244	166	896192	433	103808	47
14	791596	267	895145	166	896452	433	103548	46
15	791757	267	895045	166	896712	433	103288	45
16	791917	267	894945	166	896971	433	103029	44
17	792077	267	894846	166	897231	433	102769	43
18	792237	266	894746	166	897491	433	102509	42
19	792397	266	894646	166	897751	433	102249	41
20	792557	266	894546	166	898010	433	101990	40
21	9.792716	266	9.894446	167	9.898270	433	10.101730	39
22	792876	266	894346	167	898530	433	101470	38
23	793035	266	894246	167	898789	433	101211	37
24	793195	265	894146	167	899049	432	100951	36
25	793354	265	894046	167	899308	432	100692	35
26	793514	265	893946	167	899568	432	100432	34
27	793673	265	893846	167	899827	432	100173	33
28	793832	265	893745	167	900086	432	099914	32
29	793991	265	893645	167	900346	432	099654	31
30	794150	264	893544	167	900605	432	099395	30
31	9.794308	264	9.893444	168	9.900864	432	10.099136	29
32	794467	264	893343	168	901124	432	098876	28
33	794626	264	893243	168	901383	432	098617	27
34	794784	264	893142	168	901642	432	098358	26
35	794942	264	893041	168	901901	432	098099	25
36	795101	264	892940	168	902160	432	097840	24
37	795259	263	892839	168	902419	432	097581	23
38	795417	263	892739	168	902679	432	097321	22
39	795575	263	892638	168	902938	432	097062	21
40	795733	263	892536	168	903197	431	096803	20
41	9.795891	263	9.892435	169	9.903455	431	10.096545	19
42	796049	263	892334	169	903714	431	096285	18
43	796206	263	892233	169	903973	431	096027	17
44	796364	262	892132	169	901232	431	095768	16
45	796521	262	892030	169	904491	431	095509	15
46	796679	262	891929	169	904750	431	095250	14
47	796836	262	891827	169	905008	431	094992	13
48	796993	262	891726	169	905267	431	094733	12
49	797150	261	891624	169	905526	431	094474	11
50	797307	261	891523	170	905784	431	094216	10
51	9.797464	261	9.891421	170	9.906043	431	10.093957	9
52	797621	261	891319	170	906302	431	093698	8
53	797777	261	891217	170	906560	431	093440	7
54	797934	261	891115	170	906819	431	093181	6
55	798091	261	891013	170	907077	431	092923	5
56	798247	261	890911	170	907336	431	092664	4
57	798403	260	890809	170	907594	431	092406	3
58	798560	260	890707	170	907852	431	092148	2
59	798716	260	890605	170	908111	430	091889	1
60	798872	260	890503	170	908369	430	091631	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine.	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.798872	260	9.890503	170	9.908369	430	10.091631	60
1	799028	260	890400	171	908628	430	091372	[illegible]
2	799184	260	890298	171	908886	430	091114	[illegible]
3	799339	259	890195	171	909144	430	090856	57
4	799495	259	890093	171	909402	430	090598	56
5	799651	259	889990	171	909660	430	090340	55
6	799806	259	889888	171	909918	430	090082	54
7	799962	259	889785	171	910177	430	089823	53
8	800117	259	889682	171	910435	430	089565	52
9	800272	258	889579	171	910693	430	089307	51
10	800427	258	889477	171	910951	430	089049	50
11	9.800582	258	9.88937[illegible]	172	9.911209	430	10.088791	49
12	800737	258	889271	172	911467	430	088533	48
13	800892	258	889168	172	911724	430	088276	47
14	801047	258	889064	172	911982	430	088018	46
15	801201	258	888961	172	912240	430	087760	45
16	801356	257	888858	172	912498	430	087502	44
17	801511	257	888755	172	912756	430	087244	43
18	801665	257	888651	172	913014	429	086986	42
19	801819	257	888548	172	913271	429	086729	41
20	801973	257	888444	173	913529	429	086471	40
21	9.802128	257	9.888341	173	9.913787	429	10.086213	39
22	802282	256	888237	173	914044	429	085956	38
23	802436	256	888134	173	914302	429	085698	37
24	802589	256	888030	173	914560	429	085440	36
25	802743	256	887926	173	914817	429	085183	35
26	802897	256	887822	173	915075	429	084925	34
27	803050	256	887718	173	915332	429	084668	33
28	803204	256	887614	173	915590	429	084410	32
29	803357	255	887510	173	915847	429	084153	31
30	803511	255	887406	174	916104	429	083896	30
31	9.803664	255	9.887302	174	9.916362	429	10.083638	29
32	803817	255	887198	174	916619	429	083381	28
33	803970	255	887093	174	916877	429	083123	27
34	804123	255	886989	174	917134	429	082866	26
35	804276	254	88688[illegible]	174	917391	429	082609	25
36	804428	254	8867[illegible]	174	917648	429	082352	24
37	804581	254	8866[illegible]	174	917905	429	082095	23
38	804734	254	886571	174	918163	428	081837	22
39	804886	254	886466	174	918420	428	08[illegible]580	21
40	805039	254	886362	175	918677	428	081323	20
41	9.805191	254	9.886257	175	9.918934	428	10.081066	19
42	805843	253	886152	175	919191	428	080809	18
43	805495	253	886047	175	919448	428	080552	17
44	805647	253	885942	175	919705	428	080295	16
45	805799	253	885837	175	919962	428	080038	15
46	805951	253	885732	175	920219	428	079781	14
47	806103	253	885627	175	920476	428	079524	13
48	806254	253	885522	175	920733	428	079267	12
49	806406	252	885416	175	920990	428	079010	11
50	806557	252	885311	176	921247	428	078753	10
51	9.806709	252	9.885205	176	9.921503	428	10.078497	9
52	806860	252	885100	176	921760	428	078240	8
53	807011	252	884994	176	922017	428	077983	7
54	807163	252	884889	176	922274	428	077726	6
55	807314	252	884783	176	922530	428	077470	5
56	807465	251	884677	176	922787	428	077213	4
57	807615	251	884572	176	923044	428	076956	3
58	807766	251	884466	176	923300	428	076700	2
59	807917	251	884360	176	923557	427	076443	1
60	808067	251	884254	177	923813	427	076187	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.808067	251	9.884254	177	9.923813	427	10.076187	60
1	808218	251	884148	177	924070	427	075930	59
2	808368	251	884042	177	924327	427	075673	58
3	808519	250	883936	177	924583	427	075417	57
4	808669	250	883829	177	924840	427	075160	56
5	808819	250	883723	177	925096	427	074904	55
6	808969	250	883617	177	925352	427	074648	54
7	809119	250	883510	177	925609	427	074391	53
8	809269	250	883404	177	925865	427	074135	52
9	809419	249	883297	178	926122	427	073878	51
10	809569	249	883191	178	926378	427	073622	50
11	9.809718	249	9.883084	178	9.926634	427	10.073366	49
12	809868	249	882977	178	926890	427	073110	48
13	810017	249	882871	178	927147	427	072853	47
14	810167	249	882764	178	927403	427	072597	46
15	810316	248	882657	178	927659	427	072341	45
16	810465	248	882550	178	927915	427	072085	44
17	810614	248	882443	178	928171	427	071829	43
18	810763	248	882336	179	928427	427	071573	42
19	810912	248	882229	179	928683	427	071317	41
20	811061	248	882121	179	928940	427	071060	40
21	9.811210	248	9.882014	179	9.929196	427	10.070804	39
22	811358	247	881907	179	929452	427	070548	38
23	811507	247	881799	179	929708	427	070292	37
24	811655	247	881692	179	929964	426	070036	36
25	811804	247	881584	179	930220	426	069780	35
26	811952	247	881477	179	930475	426	069525	34
27	812100	247	881369	179	930731	426	069269	33
28	812248	247	881261	180	930987	426	069013	32
29	812396	246	881153	180	931243	426	068757	31
30	812544	246	881046	180	931499	426	068501	30
31	9.812692	246	9.880938	180	9.931755	426	10.068245	29
32	812840	246	880830	180	932010	426	067990	28
33	812988	246	880722	180	932266	426	067734	27
34	813135	246	880613	180	932522	426	067478	26
35	813283	246	880505	180	932778	426	067222	25
36	813430	245	880397	180	933033	426	066967	24
37	813578	245	880289	181	933289	426	066711	23
38	813725	245	880180	181	933545	426	066455	22
39	813872	245	880072	181	933800	426	066200	21
40	814019	245	879963	181	934056	426	065944	20
41	9.814166	245	9.879855	181	9.934311	426	10.065689	19
42	814313	245	879746	181	934567	426	065433	18
43	814460	244	879637	181	934823	426	065177	17
44	814607	244	879529	181	935078	426	064922	16
45	814753	244	879420	181	935333	426	064667	15
46	814900	244	879311	181	935589	426	064411	14
47	815046	244	879202	182	935844	426	064156	13
48	815193	244	879093	182	936100	426	063900	12
49	815339	244	878984	182	936355	426	063645	11
50	815485	243	878875	182	936610	426	063390	10
51	9.815631	243	9.878766	182	9.936866	425	10.063134	9
52	815778	243	878656	182	937121	425	062879	8
53	815924	243	878547	182	937376	425	062624	7
54	816069	243	878438	182	937632	425	062368	6
55	816215	243	878328	182	937887	425	062113	5
56	816361	243	878219	183	938142	425	061858	4
57	816507	242	878109	183	938398	425	061602	3
58	816652	242	877999	183	938653	425	061347	2
59	816798	242	877890	183	938908	425	061092	1
60	816943	242	877780	183	939163	425	060837	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.816943	242	9.877780	183	9.939163	425	10.060837	60
1	817088	242	877670	183	939418	425	060582	59
2	817233	242	877560	183	939673	425	060327	58
3	817379	242	877450	183	939928	425	060072	57
4	817524	241	877340	183	940183	425	059817	56
5	817668	241	877230	184	940438	425	059562	55
6	817813	241	877120	184	940694	425	059306	54
7	817958	241	877010	184	940949	425	059051	53
8	818103	241	876899	184	941204	425	058796	52
9	818247	241	876789	184	941458	425	058542	51
10	818392	241	876678	184	941714	425	058286	50
11	9.818536	240	9.876568	184	9.941968	425	10.058032	49
12	818681	240	876457	184	942223	425	057777	48
13	818825	240	876347	184	942478	425	057522	47
14	818969	240	876236	185	942733	425	057267	46
15	819113	240	876125	185	942988	425	057012	45
16	819257	240	876014	185	943243	425	056757	44
17	819401	240	875904	185	943498	425	056502	43
18	819545	239	875793	185	943752	425	056248	42
19	819689	239	875682	185	944007	425	055993	41
20	819832	239	875571	185	944262	425	055738	40
21	9.819976	239	9.875459	185	9.944517	425	10.055483	39
22	820120	239	875348	185	944771	424	055229	38
23	820263	239	875237	185	945026	424	054974	37
24	820406	239	875126	186	945281	424	054719	36
25	820550	238	875014	186	945535	424	054465	35
26	820693	238	874903	186	945790	424	054210	34
27	820836	238	874791	186	946045	424	053955	33
28	820979	238	874680	186	946299	424	053701	32
29	821122	238	874568	186	946554	424	053446	31
30	821265	238	874456	186	946808	424	053192	30
31	9.821407	238	9.874344	186	9.947063	424	10.052937	29
32	821550	238	874232	187	947318	424	052682	28
33	821693	237	874121	187	947572	424	052428	27
34	821835	237	874009	187	947826	424	052174	26
35	821977	237	873896	187	948081	424	051919	25
36	822120	237	873784	187	948336	424	051664	24
37	822262	237	873672	187	948590	424	051410	23
38	822404	237	873560	187	948844	424	051156	22
39	822546	237	873448	187	949099	424	050901	21
40	822688	236	873335	187	949353	424	050647	20
41	9.822830	236	9.873223	187	9.949607	424	10.050393	19
42	822972	236	873110	188	949862	424	050138	18
43	823114	236	872998	188	950116	424	049884	17
44	823255	236	872885	188	950370	424	049630	16
45	823397	236	872772	188	950625	424	049375	15
46	823539	236	872659	188	950879	424	049121	14
47	823680	235	872547	188	951133	424	048867	13
48	823821	235	872434	188	951388	424	048612	12
49	823963	235	872321	188	951642	424	048358	11
50	824104	235	872208	188	951896	424	048104	10
51	9.824245	235	9.872095	189	9.952150	424	10.047850	9
52	824386	235	871981	189	952405	424	047595	8
53	824527	235	871868	189	952659	424	047341	7
54	824668	234	871755	189	952913	424	047087	6
55	824808	234	871641	189	953167	423	046833	5
56	824949	234	871528	189	953421	423	046579	4
57	825090	234	871414	189	953675	423	046325	3
58	825230	234	871301	189	953929	423	046071	2
59	825371	234	871187	189	954183	423	045817	1
60	825511	234	871073	190	954437	423	045563	0
	Cosine		Sine		Cotang.		Tang.	M.

M	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.825511	234	9.871073	190	9.954437	423	10.045563	60
1	825651	233	870960	190	954691	423	045309	59
2	825791	233	870846	190	954945	423	045055	58
3	825931	233	870732	190	955200	423	044800	57
4	826071	233	870618	190	955454	423	044546	56
5	826211	233	870504	190	955707	423	044293	55
6	826351	233	870390	190	955961	423	044039	54
7	826491	233	870276	190	956215	423	043785	53
8	826631	233	870161	190	956469	423	043531	52
9	826770	232	870047	191	956723	423	043277	51
10	826910	232	869933	191	956977	423	043023	50
11	9.827049	232	9.869818	191	9.957231	423	10.042769	49
12	827189	232	869704	191	957485	423	042515	48
13	827328	232	869589	191	957739	423	042261	47
14	827467	232	869474	191	957993	423	042007	46
15	827606	232	869360	191	958246	423	041754	45
16	827745	232	869245	191	958500	423	041500	44
17	827884	231	869130	191	958754	423	041246	43
18	828023	231	869015	192	959008	423	040992	42
19	828162	231	868900	192	959262	423	040738	41
20	828301	231	868785	192	959516	423	040484	40
21	9.828439	231	9.868670	192	9.959769	423	10.040231	39
22	828578	231	868555	192	960023	423	039977	38
23	828716	231	868440	192	960277	423	039723	37
24	828855	230	868324	192	960531	423	039469	36
25	828993	230	868209	192	960784	423	039216	35
26	829131	230	868093	192	961038	423	038962	34
27	829269	230	867978	193	961291	423	038709	33
28	829407	230	867862	193	961545	423	038455	32
29	829545	230	867747	193	961799	423	038201	31
30	829683	230	867631	193	962052	423	037948	30
31	9.829821	229	9.867515	193	9.962306	423	10.037694	29
32	829959	229	867399	193	962560	423	037440	28
33	830097	229	867283	193	962813	423	037187	27
34	830234	229	867167	193	963067	423	036933	26
35	830372	229	867051	193	963320	423	036680	25
36	830509	229	866935	194	963574	423	036426	24
37	830646	229	866819	194	963827	423	036173	23
38	830784	229	866703	194	964081	423	035919	22
39	830921	228	866586	194	964335	423	035665	21
40	831058	228	866470	194	964588	422	035412	20
41	9.831195	228	9.866353	194	9.964842	422	10.035158	19
42	831332	228	866237	194	965095	422	034905	18
43	831469	228	866120	194	965349	422	034651	17
44	831606	228	866004	195	965602	422	034398	16
45	831742	228	865887	195	965855	422	034145	15
46	831879	228	865770	195	966109	422	033891	14
47	832015	227	865653	195	966362	422	033638	13
48	832152	227	865536	195	966616	422	033384	12
49	832288	227	865419	195	966869	422	033131	11
50	832425	227	865302	195	967123	422	032877	10
51	9.832561	227	9.865185	195	9.967376	422	10.032624	9
52	832697	227	865068	195	967629	422	032371	8
53	832833	227	864950	195	967883	422	032117	7
54	832969	226	864833	196	968136	422	031864	6
55	833105	226	864716	196	968389	422	031611	5
56	833241	226	864598	196	968643	422	031357	4
57	833377	226	864481	196	968896	422	031104	3
58	833512	226	864363	196	969149	422	030851	2
59	833648	226	864245	196	969403	422	030597	1
60	833783	226	864127	196	969656	422	030344	0
	Cosine		Sine		Cotang.		Tang.	M.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.833783	226	9.864127	196	9.969656	422	10.030344	60
1	833919	225	864010	196	969909	422	030091	59
2	834054	225	863892	197	970162	422	029838	58
3	834189	225	863774	197	970416	422	029584	57
4	834325	225	863656	197	970669	422	029331	56
5	834460	225	863538	197	970922	422	029078	55
6	834595	225	863419	197	971175	422	028825	54
7	834730	225	863301	197	971429	422	028571	53
8	834865	225	863183	197	971682	422	028318	52
9	834999	224	863064	197	971935	422	028065	51
10	835134	224	862946	198	972188	422	027812	50
11	9.835269	224	9.862827	198	9.972441	422	10.027559	49
12	835403	224	862709	198	972694	422	027306	48
13	835538	224	862590	198	972948	422	027052	47
14	835672	224	862471	198	973201	422	026799	46
15	835807	224	862353	198	973454	422	026546	45
16	835941	224	862234	198	973707	422	026293	44
17	836075	223	862115	198	973960	422	026040	43
18	836209	223	861996	198	974213	422	025787	42
19	836343	223	861877	198	974466	422	025534	41
20	836477	223	861758	199	974719	422	025281	40
21	9.836611	223	9.861638	199	9.974973	422	10.025027	39
22	836745	223	861519	199	975226	422	024774	38
23	836878	223	861400	199	975479	422	024521	37
24	837012	222	861280	199	975732	422	024268	36
25	837146	222	861161	199	975985	422	024015	35
26	837279	222	861041	199	976238	422	023762	34
27	837412	222	860922	199	976491	422	023509	33
28	837546	222	860802	199	976744	422	023256	32
29	837679	222	860682	200	976997	422	023003	31
30	837812	222	860562	200	977250	422	022750	30
31	9.837945	222	9.860442	200	9.977503	422	10.022497	29
32	838078	221	860322	200	977756	422	022244	28
33	838211	221	860202	200	978009	422	021991	27
34	838344	221	860082	200	978262	422	021738	26
35	838477	221	859962	200	978515	422	021485	25
36	838610	221	859842	200	978768	422	021232	24
37	838742	221	859721	201	979021	422	020979	23
38	838875	221	859601	201	979274	422	020726	22
39	839007	221	859480	201	979527	422	020473	21
40	839140	220	859360	201	979780	422	020220	20
41	9.839272	220	9.859239	201	9.980033	422	10.019967	19
42	839404	220	859119	201	980286	422	019714	18
43	839536	220	858998	201	980538	422	019462	17
44	839668	220	858877	201	980791	421	019209	16
45	839800	220	858756	202	981044	421	018956	15
46	839932	220	858635	202	981297	421	018703	14
47	840064	219	858514	202	981550	421	018450	13
48	840196	219	858393	202	981803	421	018197	12
49	840328	219	858272	202	982056	421	017944	11
50	840459	219	858151	202	982309	421	017691	10
51	9.840591	219	9.858029	202	9.982562	421	10.017438	9
52	840722	219	857908	202	982814	421	017186	8
53	840854	219	857786	202	983067	421	016933	7
54	840985	219	857665	203	983320	421	016680	6
55	841116	218	857543	203	983573	421	016427	5
56	841247	218	857422	203	983826	421	016174	4
57	841378	218	857300	203	984079	421	015921	3
58	841509	218	857178	203	984331	421	015669	2
59	841640	218	857056	203	984584	421	015416	1
60	841771	218	856934	203	984837	421	015163	0
	Cosine		Sine		Cotang.		Tang.	M.

46 Degrees.

M.	Sine	D.	Cosine	D.	Tang.	D.	Cotang.	
0	9.841771	218	9.856984	203	9.984837	421	10.015163	60
1	841902	218	856812	203	985090	421	014910	59
2	842033	218	856690	204	985343	421	014657	58
3	842163	217	856568	204	985596	421	014404	57
4	842294	217	856446	204	985848	421	014152	56
5	842424	217	856323	204	986101	421	013899	55
6	842555	217	856201	204	986354	421	013646	54
7	842685	217	856078	204	986607	421	013393	53
8	842815	217	855956	204	986860	421	013140	52
9	842946	217	855833	204	987112	421	012888	51
10	843076	217	855711	205	987365	421	012635	50
11	9.843206	216	9.855588	205	9.987618	421	10.012382	49
12	843336	216	855465	205	987871	421	012129	48
13	843466	216	855342	205	988123	421	011877	47
14	843595	216	855219	205	988376	421	011624	46
15	843725	216	855096	205	988629	421	011371	45
16	843855	216	854973	205	988882	421	011118	44
17	843984	216	854850	205	989134	421	010866	43
18	844114	215	854727	206	989387	421	010613	42
19	844243	215	854003	206	989640	421	010360	41
20	844372	215	854180	206	989893	421	010107	40
21	9.844502	215	9.854356	206	9.990145	421	10.009855	39
22	844631	215	854233	206	990398	421	009602	38
23	844760	215	854109	206	990651	421	009349	37
24	844889	215	853986	206	990903	421	009097	36
25	845018	215	853862	206	991156	421	008844	35
26	845147	215	853738	206	991409	421	008591	34
27	845276	214	853614	207	991662	421	008338	33
28	845405	214	853490	207	991914	421	008086	32
29	845533	214	853366	207	992167	421	007833	31
30	845662	214	853242	207	992420	421	007580	30
31	9.845790	214	9.853118	207	9.992672	421	10 007328	29
32	845919	214	852994	207	992925	421	007075	28
33	846047	214	852869	207	993178	421	006822	27
34	846175	214	852745	207	993430	421	006570	26
35	846304	214	852620	207	993683	421	006317	25
36	846432	213	852496	208	993936	421	006064	24
37	846560	213	852371	208	994189	421	005811	23
38	846688	213	852247	208	994441	421	005559	22
39	846816	213	852122	208	994694	421	005306	21
40	846944	213	851997	208	994947	421	005053	20
41	9.847071	213	9.851872	208	9.995199	421	10.004801	19
42	847199	213	851747	208	995452	421	004548	18
43	847327	213	851622	208	995705	421	004295	17
44	847454	212	851497	209	995957	421	004043	16
45	8 7582	212	851372	209	996210	421	003790	15
46	847709	212	851246	209	996463	421	003537	14
47	847836	212	851121	209	996715	421	003285	13
48	847964	212	850996	209	996968	421	003032	12
49	848091	212	850870	209	997221	421	002779	11
50	848218	212	850745	209	997473	421	002527	10
51	9.848345	212	9.850619	209	9.997726	421	10.002274	9
52	848472	211	850493	210	997979	421	002021	8
53	848599	211	850368	210	998231	421	001769	7
54	848726	211	850242	210	998484	421	001516	6
55	848852	211	850116	210	998737	421	001263	5
56	848979	211	849990	210	998989	421	001011	4
57	849106	211	849864	210	999242	421	000758	3
58	849232	211	849738	210	999495	421	000505	2
59	849359	211	849611	210	999748	421	000253	1
60	849485	211	849485	210	10.000000	421	000000	0
	Cosine		Sine		Cotang.		Tang.	M.

45 Degrees.

A TABLE

OF

NATURAL SINES,

FOR EVERY

DEGREE AND MINUTE IN THE QUADRANT.

A TABLE OF NATURAL SINES.

	0 Deg.		1 Deg.		2 Deg.		3 Deg.		4 Deg.		
M	Nat. Sine	N. Co-Sine	Nat. Sine	N. Co-Sine	Nat. Sine	N. Co-Sine	Nat. Sine	N. Co-Sine	Nat. Sine	N. Co-Sine	M
0	00000	Unit.	01745	99985	03490	99939	05234	99863	06976	99756	60
1	00029	00000	01774	99984	03519	99938	05263	99861	07005	99754	59
2	00058	00000	01803	99984	03548	99937	05292	99860	07034	99752	58
3	00087	00000	01832	99983	03577	99936	05321	99858	07063	99750	57
4	00116	00000	01862	99983	03606	99935	05350	99857	07092	99748	56
5	00145	00000	01891	99982	03685	99934	05379	99855	07121	99746	55
6	00175	00000	01920	99982	03664	99933	05408	99854	07150	99744	54
7	00204	00000	01949	99981	03693	99932	05437	99852	07179	99742	53
8	00233	00000	01978	99980	03723	99931	05466	99851	07208	99740	52
9	00262	00000	02007	99980	03752	99930	05495	99849	07237	99738	51
10	00291	00000	02036	99979	03781	99929	05524	99847	07266	99736	50
11	00320	99999	02065	99979	03810	99927	05553	99846	07295	99734	49
12	00349	99999	02094	99978	03839	99926	05582	99844	07324	99731	48
13	00378	99999	02123	99977	03868	99925	05611	99842	07353	99729	47
14	00407	99999	02152	99977	03897	99924	05640	99841	07382	99727	46
15	00436	99999	02181	99976	03926	99923	05669	99839	07411	99725	45
16	00465	9999	02211	99976	03955	99922	05698	99838	07440	99723	44
17	00495	99999	02240	99975	03984	99921	05727	99836	07469	99721	43
18	00524	99999	02269	99974	04013	99919	05756	99834	07498	99719	42
19	00553	99998	02298	99974	04042	99918	05785	99833	07527	99716	41
20	00582	99998	02327	99973	04071	99917	05814	99831	07556	99714	40
21	00611	99998	02356	99972	04100	99916	05844	99829	07585	99712	39
22	00640	99998	02385	99972	04129	99915	05873	99827	07614	99710	38
23	00669	99998	02414	99971	04159	99913	05902	99826	07643	99708	37
24	00698	99998	02443	99970	04188	99912	05931	99824	07672	99705	36
25	00727	99997	02472	99969	04217	99911	05960	99822	07701	99703	35
26	00756	99997	02501	99969	04246	99910	05989	99821	07730	99701	34
27	00785	99997	02530	99968	04275	99909	06018	99819	07759	99699	33
28	00814	99997	02560	99967	04304	99907	06047	99817	07788	99696	32
29	00844	99996	02589	99966	04333	99906	06076	99815	07817	99694	31
30	00873	99996	02618	99366	04362	99905	06105	99813	07846	99692	30
31	00902	99996	02647	99965	04391	99904	06134	99812	07875	99689	29
32	00931	99996	02676	99964	04420	99902	06163	99810	07904	99687	28
33	00960	99995	02705	99963	04449	99901	06192	99808	07933	99685	27
34	00989	99995	02734	99963	04478	99900	06221	99806	07962	99683	26
35	01018	99995	02763	99962	04507	99898	06250	99804	07991	99680	25
36	01047	99995	02792	99961	04536	99897	06279	99803	08020	99678	24
37	01076	99994	02821	99960	04565	99896	06308	99801	08049	99676	23
38	01105	99994	02850	99959	04594	99894	06337	99799	08078	99673	22
39	01134	99994	02879	99959	04623	99893	06366	99797	08107	99671	21
40	01164	99993	02908	99958	04653	99892	06395	99795	08136	99668	20
41	01193	99993	02938	99957	04682	99890	06424	99793	08165	99666	19
42	01222	99993	02967	99956	04711	99889	06453	99792	08194	99664	18
43	01251	99992	02996	99955	04740	99888	06482	99790	08223	99661	17
44	01280	99992	03025	99954	04769	99886	06511	99788	08252	99659	16
45	01309	99991	03054	99953	04798	99885	06540	99786	08281	99657	15
46	01338	99991	03083	99952	04827	99883	06569	99784	08310	99654	14
47	01367	99991	03112	99952	04856	99882	06598	99782	08339	99652	13
48	01396	99990	03141	99951	04885	99881	06627	99780	08368	99649	12
49	01425	99990	03170	99950	04914	99879	06656	99778	08397	99647	11
50	01454	99989	03199	99949	04943	99878	06685	99776	08426	99644	10
51	01483	99989	03228	99948	04972	99876	06714	99774	08455	99642	9
52	01513	99989	03257	99947	05001	99875	06743	99772	08484	99639	8
53	01542	99988	03286	99946	05030	99873	06773	99770	08513	99637	7
54	01571	99988	03316	99945	05059	99872	06802	99768	08542	99635	6
55	01600	99987	03345	99944	05088	99870	06831	99766	08571	99632	5
56	01629	99987	03374	99943	05117	99869	06860	99764	08600	99630	4
57	01658	99986	03403	99942	05146	99867	06889	99762	08629	99627	3
58	01687	99986	03432	99941	05175	99866	06918	99760	08658	99625	2
59	01716	99985	03461	99940	05205	99864	06947	99758	08687	99622	1
M	N. Co-Sine	Nat. Sine	N. Co-Sine	Nat. Sine	N. Co-Sine	Nat. Sine	N. Co-Sine	Nat. Sine	N. Co-Sine	Nat. Sine	M
	89 Deg.		88 Deg.		87 Deg.		86 Deg.		85 Deg.		

	5 Deg.		6 Deg.		7 Deg.		8 Deg.		9 Deg.		
M	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	M
0	08716	99619	10453	99452	12187	99255	13917	99027	15643	98769	60
1	08745	99617	10482	99449	12216	99251	13946	99023	15672	98764	59
2	08774	99614	10511	99446	12245	99248	13975	99019	15701	98760	58
3	08803	99612	10540	99443	12274	99244	14004	99015	15730	98755	57
4	08831	99609	10569	99440	12302	99240	14033	99011	15758	98751	56
5	08860	99607	10597	99437	12331	99237	14061	99006	15787	98746	55
6	08889	99604	10626	99434	12360	99233	14090	99002	15816	98741	54
7	08918	99602	10655	99431	12389	99230	14119	98998	15845	98737	53
8	08947	99599	10684	99428	12418	99226	14148	98994	15873	98732	52
9	08976	99596	10713	99424	12447	99222	14177	98990	15902	98728	51
10	09005	99594	10742	99421	12476	99219	14205	98986	15931	98723	50
11	09034	99591	10771	99418	12504	99215	14234	98982	15959	98718	49
12	09063	99588	10800	99415	12533	99211	14263	98978	15988	98714	48
13	09092	99586	10829	99412	12562	99208	14292	98973	16017	98709	47
14	09121	99583	10858	99409	12591	99204	14320	98969	16046	98704	46
15	09150	99580	10887	99406	12620	99200	14349	98965	16074	98700	45
16	09179	99578	10916	99402	12649	99197	14378	98961	16103	98695	44
17	09208	99575	10945	99399	12678	99193	14407	98957	16132	98690	43
18	09237	99572	10973	99396	12706	99189	14436	98953	16160	98686	42
19	09266	99570	11002	99393	12735	99186	14464	98948	16189	98681	41
20	09295	99567	11031	99390	12764	99182	14493	98944	16218	98676	40
21	09324	99564	11060	99386	12793	99178	14522	98940	16246	98671	39
22	09353	99562	11089	99383	12822	99175	14551	98936	16275	98667	38
23	09382	99559	11118	99380	12851	99171	14580	98931	16304	98662	37
24	09411	99556	11147	99377	12880	99167	14608	98927	16333	98657	36
25	09440	99553	11176	99374	12908	99163	14637	98923	16361	98652	35
26	09469	99551	11205	99370	12937	99160	14666	98919	16390	98648	34
27	09498	99548	11234	99367	12966	99156	14695	98914	16419	98643	33
28	09527	99545	11263	99364	12995	99152	14723	98910	16447	98638	32
29	09556	99542	11291	99360	13024	99148	14752	98906	16476	98633	31
30	09535	99540	11320	99357	13053	99144	14781	98902	16505	98629	30
31	09614	99537	11349	99354	13081	99141	14810	98897	16533	98624	29
32	09642	99534	11378	99351	13110	99137	14838	98893	16562	98619	28
33	09671	99531	11407	99347	13139	99133	14867	98889	16591	98614	27
34	09700	99528	11436	99344	13168	99129	14896	98884	16620	98609	26
35	09729	99526	11465	99341	13197	99125	14925	98880	16648	98604	25
36	09758	99523	11494	99337	13226	99122	14954	98876	16677	98600	24
37	09787	99520	11523	99334	13254	99118	14982	98871	16706	98595	23
38	09816	99517	11552	99331	13283	99114	15011	98867	16734	98590	22
39	09845	99514	11580	99327	13312	99110	15040	98863	16763	98585	21
40	09874	99511	11609	99324	13341	99106	15069	98858	16792	98580	20
41	09903	99508	11638	99320	13370	99102	15097	98854	16820	98575	19
42	09932	99506	11667	99317	13399	99098	15126	98849	16849	98570	18
43	09961	99503	11696	99314	13427	99094	15155	98845	16878	98565	17
44	09990	99500	11725	99310	13456	99091	15184	98841	16906	98561	16
45	10019	99497	11754	99307	13485	99087	15212	98836	16935	98556	15
46	10048	99494	11783	99303	13514	99083	15241	98832	16964	98551	14
47	10077	99491	11812	99300	13543	99079	15270	98827	16992	98546	13
48	10106	99488	11840	99297	13572	99075	15292	98823	17021	98541	12
49	10135	99485	11869	99293	13600	99071	15327	98818	17050	98536	11
50	10164	99482	11898	99290	13629	99067	15356	98814	17078	98531	10
51	10192	99479	11927	99286	13658	99063	15385	98809	17107	98526	9
52	10221	99476	11956	99283	13687	99059	15414	98805	17136	98521	8
53	10250	99473	11985	99279	13716	99055	15442	98800	17164	98516	7
54	10279	99470	12014	99276	13744	99051	15471	98796	17193	98511	6
55	10308	99467	12043	99272	13773	99047	15500	98791	17222	98506	5
56	10337	99464	12071	99269	13802	99043	15529	98787	17250	98501	4
57	10366	99461	12100	99265	13831	99039	15557	98782	17279	98496	3
58	10395	99458	12129	99262	13860	99035	15586	98778	17308	98491	2
59	10424	99455	12158	99258	13889	99031	15615	98773	17336	98486	1
M	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	M
	84 Deg.		83 Deg.		82 Deg.		81 Deg.		80 Deg.		

	10 Deg.		11 Deg.		12 Deg.		13 Deg.		14 Deg.		
M	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	M
0	17365	98481	19081	98163	20791	97815	22495	97437	24192	97030	60
1	17393	98476	19109	98157	20820	97809	22523	97430	24220	97023	59
2	17422	98471	19138	98152	20848	97803	22552	97424	24249	97015	58
3	17451	98466	19167	98146	20877	97797	22580	97417	24277	97008	57
4	17479	98461	19195	98140	20905	97791	22608	97411	24305	97001	56
5	17508	98455	19224	98135	20933	97784	22637	97404	24333	96994	55
6	17537	98450	19252	98129	20962	97778	22665	97398	24362	96987	54
7	17565	98445	19281	98124	20990	97772	22693	97391	24390	96980	53
8	17594	98440	19309	98118	21019	97766	22722	97384	24418	96973	52
9	17623	98435	19338	98112	21047	97760	22750	97378	24446	96966	51
10	17651	98430	19366	98107	21076	97754	22778	97371	24474	96959	50
11	17680	98425	19395	98101	21104	97748	22807	97365	24503	96952	49
12	17708	98420	19423	98096	21132	97742	22835	97358	24531	96945	48
13	17737	98414	19452	98090	21161	97735	22863	97351	24559	96937	47
14	17766	98409	19481	98084	21189	97729	22892	97345	24587	96930	46
15	17794	98404	19509	98079	21218	97723	22920	97338	24615	96923	45
16	17823	98399	19538	98073	21246	97717	22948	97331	24644	96916	44
17	17852	98394	19566	98067	21275	97711	22977	97325	24672	96909	43
18	17880	98389	19595	98061	21303	97705	23005	97318	24700	96902	42
19	17909	98383	19623	98056	21331	97698	23033	97311	24728	96894	41
20	17937	98378	19652	98050	21360	97692	23062	97304	24756	96887	40
21	17966	98373	19680	98044	21388	97686	23090	97298	24784	96880	39
22	17995	98368	19709	98039	21417	97680	23118	97291	24813	96873	38
23	18023	98362	19737	98033	21445	97673	23146	97284	24841	96866	37
24	18052	98357	19766	98027	21474	97667	23175	97278	24869	96858	36
25	18081	98352	19794	98021	21502	97661	23203	97271	24897	96851	35
26	18109	98347	19823	98016	21530	97655	23231	97264	24925	96844	34
27	18138	98341	19851	98010	21559	97648	23260	97257	24953	96837	33
28	18166	98336	19880	98004	21587	97642	23288	97251	24982	96829	32
29	18195	98331	19908	97998	21616	97636	23316	97244	25010	96822	31
30	18224	98325	19937	97992	21644	97630	23345	97237	25038	96815	30
31	18252	98320	19965	97987	21672	97623	23373	97230	25066	96807	29
32	18281	98315	19994	97981	21701	97617	23401	97223	25094	96800	28
33	18309	98310	20022	97975	21729	97611	23429	97217	25122	96793	27
34	18338	98304	20051	97969	21758	97604	23458	97210	25151	96786	26
35	18367	98299	20079	97963	21786	97598	23486	97203	25179	96778	25
36	18395	98294	20108	97958	21814	97592	23514	97196	25207	96771	24
37	18424	98288	20136	97952	21843	97585	23542	97189	25235	96764	23
38	18452	98283	20165	97946	21871	97579	23571	97182	25263	96756	22
39	18481	98277	20193	97940	21899	97573	23599	97176	25291	96749	21
40	18509	98272	20222	97934	21928	97566	23627	97169	25320	96742	20
41	18538	98267	20250	97928	21956	97560	23656	97162	25348	96734	19
42	18567	98261	20279	97922	21985	97553	23684	97155	25376	96727	18
43	18595	98256	20307	97916	22013	97547	23712	97148	25404	96719	17
44	18624	98250	20336	97910	22041	97541	23740	97141	25432	96712	16
45	18652	98245	20364	97905	22070	97534	23769	97134	25460	96705	15
46	18681	98240	20393	97899	22098	97528	23797	97127	25488	96697	14
47	18710	98234	20421	97893	22126	97521	23825	97120	25516	96690	13
48	18738	98229	20450	97887	22155	97515	23853	97113	25545	96682	12
49	18767	98223	20478	97881	22183	97508	23882	97106	25573	96675	11
50	18795	98218	20507	97875	22212	97502	23910	97100	25601	96667	10
51	18824	98212	20535	97869	22240	97496	23938	97093	25629	96660	9
52	18852	98207	20563	97863	22268	97489	23966	97086	25657	96653	8
53	18881	98201	20592	97857	22297	97483	23995	97079	25685	96645	7
54	18910	98196	20620	97851	22325	97476	24023	97072	25713	96638	6
55	18938	98190	20649	97845	22353	97470	24051	97065	25741	96630	5
56	18967	98185	20677	97839	22382	97463	24079	97058	25769	96623	4
57	18995	98179	20706	97833	22410	97457	24108	97051	25798	96615	3
58	19024	98174	20734	97827	22438	97450	24136	97044	25826	96608	2
59	19052	98168	20763	97821	22467	97444	24164	97037	25854	96600	1
M	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	M
	79 Deg.		78 Deg.		77 Deg.		76 Deg.		75 Deg.		

M	15 Deg.		16 Deg.		17 Deg.		18 Deg.		19 Deg.		M
	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS	
0	25882	96593	27564	96126	29237	95630	30902	95106	32557	94552	60
1	25910	96585	27592	96118	29265	95622	30929	95097	32584	94542	59
2	25938	96578	27620	96110	29293	95613	30957	95088	32612	94533	58
3	25966	96570	27648	96102	29321	95605	30985	95079	32639	94523	57
4	25994	96562	27676	96094	29348	95596	31012	95070	32667	94514	56
5	26022	96555	27704	96086	29376	95588	31040	95061	32694	94504	55
6	26050	96547	27731	96078	29404	95579	31068	95052	32722	94495	54
7	26079	96540	27759	96070	29432	95571	31095	95043	32749	94485	53
8	26107	96532	27787	96062	29460	95562	31123	95033	32777	94476	52
9	26135	96524	27815	96054	29487	95554	31151	95024	32804	94466	51
10	26163	96517	27843	96046	29515	95545	31178	95015	32832	94457	50
11	26191	96509	27871	96037	29543	95536	31206	95006	32859	94447	49
12	26219	96502	27899	96029	29571	95528	31233	94997	32887	94438	48
13	26247	96494	27927	96021	29599	95519	31261	94988	32914	94428	47
14	26275	96486	27955	96013	29626	95511	31289	94979	32942	94418	46
15	26303	96479	27983	96005	29654	95502	31316	94970	32969	94409	45
16	26331	96471	28011	95997	29682	95493	31344	94961	32997	94399	44
17	26359	96463	28039	95989	29710	95485	31372	94952	33024	94390	43
18	26387	96456	28067	95981	29737	95476	31399	94943	33051	94380	42
19	26415	96448	28095	95972	29765	95467	31427	94933	33079	94370	41
20	26443	96440	28123	95964	29793	95459	31454	94924	33106	94361	40
21	26471	96433	28150	95956	29821	95450	31482	94915	33134	94351	39
22	26500	96425	28178	95948	29849	95441	31510	94906	33161	94342	38
23	26528	96417	28206	95940	29876	95433	31537	94897	33189	94332	37
24	26556	96410	28234	95931	29904	95424	31565	94888	33216	94322	36
25	26584	96402	28262	95923	29932	95415	31593	94878	33244	94313	35
26	26612	96394	28290	95915	29960	95407	31620	94869	33271	94303	34
27	26640	96386	28318	95907	29987	95398	31648	94860	33298	94293	33
28	26668	96379	28346	95898	30015	95389	31675	94851	33326	94284	32
29	26696	96371	28374	95890	30043	95380	31703	94842	33353	94274	31
30	26724	96363	28402	95882	30071	95372	31730	94832	33381	94264	30
31	26752	96355	28429	95874	30098	95363	31758	94823	33408	94254	29
32	26780	96347	28457	95865	30126	95354	31786	94814	33436	94245	28
33	26808	96340	28485	95857	30154	95345	31813	94805	33463	94235	27
34	26836	96332	28513	95849	30182	95337	31841	94795	33490	94225	26
35	26864	96324	28541	95841	30209	95328	31868	94786	33518	94215	25
36	26892	96316	28569	95832	30237	95319	31896	94777	33545	94206	24
37	26920	96308	28597	95824	30265	95310	31923	94768	33573	94196	23
38	26948	96301	28625	95816	30292	95301	31951	94758	33600	94186	22
39	26976	96293	28652	95807	30320	95293	31979	94749	33627	94176	21
40	27004	96285	28680	95799	30348	95284	32006	94740	33655	94167	20
41	27032	96277	28708	95791	30376	95275	32034	94730	33682	94157	19
42	27060	96269	28736	95782	30403	95266	32061	94721	33710	94147	18
43	27088	96261	28764	95774	30431	95257	32089	94712	33737	94137	17
44	27116	96253	28792	95766	30459	95248	32116	94702	33764	94127	16
45	27144	96246	28820	95757	30486	95240	32144	94693	33792	94118	15
46	27172	96238	28847	95749	30514	95231	32171	94684	33819	94108	14
47	27200	96230	28875	95740	30542	95222	32199	94674	33846	94098	13
48	27228	96222	28903	95732	30570	95213	32227	94665	33874	94088	12
49	27256	96214	28931	95724	30597	95204	32254	94656	33901	94078	11
50	27284	96206	28959	95715	30625	95195	32282	94646	33929	94068	10
51	27312	96198	28987	95707	30653	95186	32309	94637	33956	94058	9
52	27340	96190	29015	95698	30680	95177	32337	94627	33983	94049	8
53	27368	96182	29042	95690	30708	95168	32364	94618	34011	94039	7
54	27396	96174	29070	95681	30736	95159	32392	94609	34038	94029	6
55	27424	96166	29098	95673	30763	95150	32419	94599	34065	94019	5
56	27452	96158	29126	95664	30791	95142	32447	94590	34093	94009	4
57	27480	96150	29154	95656	30819	95133	32474	94580	34120	93999	3
58	27508	96142	29182	95647	30846	95124	32502	94571	34147	93989	2
59	27536	96134	29209	95639	30874	95115	32529	94561	34175	93979	1
M	N. CS	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	M
	74 Deg.		73 Deg.		72 Deg.		71 Deg.		70 Deg.		

	20 Deg.		21 Deg.		22 Deg.		23 Deg.		24 Deg.		
M	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	M
0	34202	93969	35837	93358	37461	92718	39073	92050	40674	9135-	60
1	34229	93959	35864	93348	37488	92707	39100	92039	40700	9134.	59
2	34257	93949	35891	93337	37515	92697	39127	92028	40727	91331	58
3	34284	93939	35918	93327	37542	92686	39153	92016	40753	91319	57
4	34311	93929	35945	93316	37569	92675	39180	92005	40780	91307	56
5	34339	93919	35973	93306	37595	92664	39207	91994	40806	91295	55
6	34366	93909	36000	93295	37622	92653	39234	91982	40833	91283	54
7	34393	93899	36027	93285	37649	92642	39260	91971	40860	91272	53
8	34421	93889	36054	93274	37676	92631	39287	91959	40886	91260	52
9	34448	93879	36081	93264	37703	92620	39314	91948	40913	91248	51
10	34475	93869	36108	93253	37730	92609	39341	91936	40939	91236	50
11	34503	93859	36135	93243	37757	92598	39367	91925	40966	91224	49
12	34530	93849	36162	98232	37784	92587	39394	91914	40992	91212	48
13	34557	93839	36190	93222	37811	92576	39421	91902	41019	91200	47
14	34584	93829	36217	93211	37838	92565	39448	91891	41045	91188	46
15	34612	93819	36244	93201	37865	92554	39474	91879	41072	91176	45
16	34639	98809	36271	93190	37892	92543	39501	91868	41098	91164	44
17	34666	93799	36298	93180	37919	92532	39528	91856	41125	91152	43
18	34694	93789	36325	93169	37946	92521	39556	91845	41151	91140	42
19	34721	93779	36352	93159	37973	92510	39581	91833	41178	91128	41
20	34748	93769	36379	93148	37999	92499	39608	91822	41204	91116	40
21	34775	93759	36406	93137	38026	92488	39635	91810	41231	91104	39
22	34803	93748	36434	93127	38053	92477	39661	91799	41257	91092	38
23	34830	93738	36461	93116	38080	92466	39688	91787	41284	91080	37
24	34857	93728	36488	93106	38107	92455	39715	91775	41310	91068	36
25	34884	93718	36515	93095	38134	92444	39741	91764	41337	91056	35
26	34912	93708	36542	93084	38161	92432	39768	91752	41363	91044	34
27	34939	93698	36569	93074	38188	92421	39795	91741	41390	91032	33
28	34966	93688	36596	93063	38215	92410	39822	91729	41416	91020	32
29	34993	93677	36623	93052	38241	92399	39848	91718	41443	91008	31
30	35021	93667	36650	93042	38268	92388	39875	91706	41469	90996	30
31	35048	93657	36677	93031	38295	92377	39902	91694	41496	90984	29
32	35075	93647	36704	93020	38322	92366	39928	91683	41522	90972	28
33	35102	93637	36731	93010	38349	92355	39955	91671	41549	90960	27
34	35130	93626	36758	92999	38376	92343	39982	91660	41575	90948	26
35	35157	93616	36785	92988	38403	92332	40008	91648	41602	90936	25
36	35183	93606	36812	92978	38430	92321	40035	91636	41628	90924	24
37	35211	93596	36839	92967	38456	92310	40062	91625	41655	90911	23
38	35239	93585	36867	92956	38483	92299	40088	91613	41681	90899	22
39	35266	93575	36894	92945	38510	92287	40115	91601	41707	90887	21
40	35293	93565	36921	92935	38537	92276	40141	91590	41734	90875	20
41	35320	93555	36948	92924	38564	92265	40168	91578	41760	90863	19
42	35347	93544	36975	92913	38591	92254	40195	91566	41787	90851	18
43	35375	93534	37002	92902	38617	92243	40221	91555	41813	90839	17
44	35402	93524	37029	92892	38644	92231	40248	91543	41840	90826	16
45	35429	93514	37056	92881	38671	92220	40275	91531	41866	90814	15
46	35456	93503	37083	92870	38698	92209	40301	91519	41892	90802	14
47	35484	93493	37110	92859	38725	92198	40328	91508	41919	90790	13
48	35511	93483	37137	92849	38752	92186	40355	91496	41945	90778	12
49	35538	93472	37164	92838	38778	92175	40381	91484	41972	90766	11
50	35565	93462	37191	92827	38805	92164	40408	91472	41998	90753	10
51	35592	93452	37218	92816	38832	92152	40434	91461	42024	90741	9
52	35619	93441	37245	92805	38859	92141	40461	91449	42051	90729	8
53	35647	93431	37272	92794	38886	92130	40488	91437	42077	90717	7
54	35674	93420	37299	92784	38912	92119	40514	91425	42104	90704	6
55	35701	93410	37326	92773	38939	92107	40541	91414	42130	90692	5
56	35728	93400	37353	92762	38966	92096	40567	91402	42156	90680	4
57	35755	93389	37380	92751	38993	92085	40594	91390	42183	90668	3
58	35782	93379	37407	92740	39020	92073	40621	91378	42209	90655	2
59	35810	93368	37434	92729	39046	92062	40647	91366	42235	90643	1
M	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	M
	69 Deg.		68 Deg.		67 Deg.		66 Deg.		65 Deg.		

	25 Deg.		26 Deg.		27 Deg.		28 Deg.		29 Deg.		
M	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	M
0	42262	90631	43837	89879	45399	89101	46947	88295	48481	87462	60
1	42288	90618	43863	89867	45425	89087	46973	88281	48506	87448	59
2	42315	90606	43889	89854	45451	89074	46999	88267	48532	87434	58
3	42341	90594	43916	89841	45477	89061	47024	88254	48557	87420	57
4	42367	90582	43942	89828	45503	89048	47050	88240	48583	87406	56
5	42394	90569	43968	89816	45529	89035	47076	88226	48608	87391	55
6	42420	90557	43994	89803	45554	89021	47101	88213	48634	87377	54
7	42446	90545	44020	89790	45580	89008	47127	88199	48659	87363	53
8	42473	90532	44046	89777	45606	88995	47153	88185	48684	87349	52
9	42499	90520	44072	89764	45632	88981	47178	88172	48710	87335	51
10	42525	90507	44098	89752	45658	88968	47204	88158	48735	87321	50
11	42552	90495	44124	89739	45684	88955	47229	88144	48761	87306	49
12	42578	90483	44151	89726	45710	88942	47255	88130	48786	87292	48
13	42604	90470	44177	89713	45736	88928	47281	88117	48811	87278	47
14	42631	90458	44203	89700	45762	88915	47306	88103	48837	87264	46
15	42657	90446	44229	89687	45787	88902	47332	88089	48862	87250	45
16	42683	90433	44255	89674	45813	88888	47358	88075	48888	87235	44
17	42709	90421	44281	89662	45839	88875	47383	88062	48913	87221	43
18	42736	90408	44307	89649	45865	88862	47409	88048	48938	87207	42
19	42762	90396	44333	89636	45891	88848	47434	88034	48964	87193	41
20	42788	90383	44359	89623	45917	88835	47460	88020	48989	87178	40
21	42815	90371	44385	89610	45942	88822	47486	88006	49014	87164	39
22	42841	90358	44411	89597	45968	88808	47511	87993	49040	87150	38
23	42867	90346	44437	89584	45994	88795	47537	87979	49065	87136	37
24	42894	90334	44464	89571	46020	88782	47562	87965	49090	87121	36
25	42920	90321	44490	89558	46046	88768	47588	87931	49116	87107	35
26	42946	90309	44516	89545	46072	88755	47614	87937	49141	87093	34
27	42972	90296	44542	89532	46097	88741	47639	87923	49166	87079	33
28	42999	90284	44568	89519	46123	88728	47665	87909	49192	87064	32
29	43025	90271	44594	89506	46149	88715	47690	87896	49217	87050	31
30	43051	90259	44620	89493	46175	88701	47716	87882	49242	87036	30
31	43077	90246	44646	89480	46201	88688	47741	87868	49268	87021	29
32	43104	90233	44672	89467	46226	88674	47767	87854	49293	87007	28
33	43130	90221	44698	89454	46252	88661	47793	87840	49318	86993	27
34	43156	90208	44724	89441	46278	88647	47818	87826	49344	86978	26
35	43182	90196	44750	89428	46304	88634	47844	87812	49369	86964	25
36	43209	90183	44776	89415	46330	88620	47869	87798	49394	86949	24
37	43235	90171	44802	89402	46355	88607	47895	87784	49419	86935	23
38	43261	90158	44828	89389	46381	88593	47920	87770	49445	86921	22
39	43287	90146	44854	89376	46407	88580	47946	87756	49470	86906	21
40	43313	90133	44880	89363	46433	88566	47971	87743	49495	86892	20
41	43340	90120	44906	89350	46458	88553	47997	87729	49521	86878	19
42	43366	90108	44932	89337	46484	88539	48022	87715	49546	86863	18
43	43392	90095	44958	89324	46510	88526	48048	87701	49571	86849	17
44	43418	90082	44984	89311	46536	88512	48073	87687	49596	86834	16
45	43445	90070	45010	89298	46561	88499	48099	87673	49622	86820	15
46	43471	90057	45036	89285	46587	88485	48124	87659	49647	86805	14
47	43497	90045	45062	89272	46613	88472	48150	87645	49672	86791	13
48	43523	90032	45088	89259	46639	88458	48175	87631	49697	86777	12
49	43549	90019	45114	89245	46664	88445	48201	87617	49723	86762	11
50	43575	90007	45140	89232	46690	88431	48226	87603	49748	86748	10
51	43602	89994	45166	89219	46716	88417	48252	87589	49773	86733	9
52	43628	89981	45192	89206	46742	88404	48277	87575	49798	86719	8
53	43654	89968	45218	89193	46767	88390	48303	87561	49824	86704	7
54	43680	89956	45243	89180	46793	88377	48328	87546	49849	86690	6
55	43706	89943	45269	89167	46819	88363	48354	87532	49874	86675	5
56	43733	89930	45295	89153	46844	88349	48379	87518	49899	86661	4
57	43759	89918	45321	89140	46870	88336	48405	87504	49924	86646	3
58	43785	89905	45347	89127	46896	88322	48430	87490	49950	86632	2
59	43811	89892	45373	89114	46921	88308	48456	87476	49975	86617	1
M	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	M
	64 Deg.		63 Deg.		62 Deg.		61 Deg.		60 Deg.		

	30 Deg.		31 Deg.		32 Deg.		33 Deg.		34 Deg.		
M	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	M
0	50000	86603	51504	85717	52992	84805	54464	83867	55919	82904	60
1	50025	86588	51529	85702	53017	84789	54488	83851	55943	82887	59
2	50050	86573	51554	85687	53041	84774	54513	83835	55968	82871	58
3	50076	86559	51579	85672	53066	84759	54537	83819	55992	82855	57
4	50101	86544	51604	85657	53091	84743	54561	83804	56016	82839	56
5	50126	86530	51628	85642	53115	84728	54586	83788	56040	82822	55
6	50151	86515	51653	85627	53140	84712	54610	83772	56064	82806	54
7	50176	86501	51678	85612	53164	84697	54635	83756	56088	82790	53
8	50201	86486	51703	85597	53189	84681	54659	83740	50112	82773	52
9	50227	86471	51728	85582	53214	84666	54683	83724	56136	82757	51
10	50252	86457	51753	85567	53238	84650	54708	83708	56160	82741	50
11	50277	86442	51778	85551	53263	84635	54732	83692	56184	82724	49
12	50302	86427	51803	85536	53288	84619	54756	83676	56208	82708	48
13	50327	86413	51828	85521	53312	84604	54781	83660	56232	82692	47
14	50352	86398	51852	85506	53337	84588	54805	83645	56256	82675	46
15	50377	86384	51877	85491	53361	84573	54829	83629	56280	82659	45
16	50403	86369	51902	85476	53386	84557	54854	83613	56305	82643	44
17	50428	86354	51927	85461	53411	84542	54878	83597	56329	82626	43
18	50453	86340	51952	85446	53435	84526	54902	83581	56353	82610	42
19	50478	86325	51977	85431	53460	84511	54927	83565	56377	82593	41
20	50503	86310	52002	85416	53484	84495	54951	83549	56401	82577	40
21	50528	86295	52026	85401	53509	84480	54975	83533	56425	82561	39
22	50553	86281	52051	85385	53534	84464	54999	83517	56449	82544	38
23	50578	86266	52076	85370	53558	84448	55024	83501	56473	82528	37
24	50603	86251	52101	85355	53583	84433	55048	83485	56497	82511	36
25	50628	86237	52126	85340	53607	84417	55072	83469	56521	82495	35
26	50654	86222	52151	85325	53632	84402	55097	83453	56545	82478	34
27	50679	86207	52175	85310	53656	84386	55121	83437	56569	82462	33
28	50704	86192	52200	85294	58681	84370	55145	83421	56593	82446	32
29	50729	86178	52225	85279	53705	84355	55169	83405	56617	82429	31
30	50754	86163	52250	85264	53730	84339	55194	83389	56641	82413	30
31	50779	86148	52275	85249	53754	84324	55218	83373	56665	82396	29
32	50804	86133	52299	85234	53779	84308	55242	83356	56689	82380	28
33	50829	86119	52324	85218	53804	84292	55266	83340	56713	82363	27
34	50854	86104	52349	85203	53828	84277	55291	83324	56736	82347	26
35	50873	86089	52374	85188	53853	84261	55315	83308	56760	82330	25
36	50904	86074	52399	85173	53877	84245	55339	83292	56784	82314	24
37	50929	86059	52423	85157	53902	84230	55363	83276	56808	82297	23
38	50954	86045	52448	85142	53926	84214	55388	83260	56832	82281	22
39	50979	86030	52473	85127	53951	84198	55412	83244	56856	82264	21
40	51004	86015	52498	85112	53975	84182	55436	83228	56880	82248	20
41	51029	86000	52522	85096	54000	84167	55460	83212	56904	82231	19
42	51054	85985	52547	85081	54024	84151	55484	83195	56928	82214	18
43	51079	85970	52572	85066	54049	84135	55509	83179	56952	82198	17
44	51104	85956	52597	85051	54073	84120	55533	83163	56976	82181	16
45	51129	85941	52621	85035	54097	84104	55557	83147	57000	82165	15
46	51154	85926	52646	85020	54122	84088	55581	83131	57024	82148	14
47	51179	85911	52671	85005	54146	84072	55605	83116	57047	82132	13
48	51204	85896	52696	84989	54171	84057	55630	83098	57071	82115	12
49	51229	85881	52720	84974	54195	84041	55654	83082	57095	82098	11
50	51254	85866	52745	84959	54220	84025	55678	83066	57119	82082	10
51	51279	85851	52770	84943	54244	84009	55702	83050	57143	82065	9
52	51304	85836	52794	84928	54269	83994	55726	83034	57167	82048	8
53	51329	85821	52819	84913	54293	83978	55750	83017	57191	82032	7
54	51354	85806	52844	84897	54317	83962	55775	83001	57215	82015	6
55	51379	85792	52869	84882	54342	83946	55799	82985	57238	81999	5
56	51404	85777	52893	84866	54366	83930	55823	82969	57262	81982	4
57	51429	85762	52918	84851	54391	83915	55847	82953	57286	81965	3
58	51454	85747	52943	84836	54415	83899	55871	82936	57310	81949	2
59	51479	85732	52967	84820	54440	83883	55895	82920	57334	81932	1
M	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	M.
	59 Deg.		58 Deg.		57 Deg.		56 Deg.		55 Deg.		

M	35 Deg. N. S.	35 Deg. N. CS.	36 Deg. N. S.	36 Deg. N. CS.	37 Deg. N. S.	37 Deg. N. CS.	38 Deg. N. S.	38 Deg. N. CS.	39 Deg. N. S.	39 Deg. N. CS.	M
0	57358	81915	58779	80902	60182	79864	61566	78801	62932	77715	60
1	57381	81899	58802	80885	60205	79846	61589	78783	62955	77696	59
2	57405	81882	58826	80867	60228	79829	61612	78765	62977	77678	58
3	57429	81865	58849	80850	60251	79811	61635	78747	63000	77660	57
4	57453	81848	58873	80833	60274	79793	61658	78729	63022	77641	56
5	57477	81832	58896	80816	60298	79776	61681	78711	63045	77623	55
6	57501	81815	58920	80799	60321	79758	61704	78694	63068	77605	54
7	57524	81798	58943	80782	60344	79741	61726	78676	63090	77586	53
8	57548	81782	58967	80765	60367	79723	61749	78658	63113	77568	52
9	57572	81765	58990	80748	60390	79706	61772	78640	63135	77550	51
10	57596	81748	59014	80730	60414	79688	61795	78622	63158	77531	50
11	57619	81731	59037	80713	60437	79671	61818	78604	63180	77513	49
12	57643	81714	59061	80696	60460	79653	61841	78586	63203	77494	48
13	57667	81698	59084	80679	60483	79635	61864	78568	63225	77476	47
14	57691	81681	59108	80662	60506	79618	61887	78550	63248	77458	46
15	57715	81664	59131	80644	60529	79600	61909	78532	63271	77439	45
16	57738	81647	59154	80627	60553	79583	61932	78514	63293	77421	44
17	57762	81631	59178	80610	60576	79565	61955	78496	63316	77402	43
18	57786	81614	59201	80593	60599	79547	61978	78478	63338	77384	42
19	57810	81597	59225	80576	60622	79530	62001	78460	63361	77366	41
20	57833	81580	59248	80558	60645	79512	62024	78442	63383	77347	40
21	57857	81563	59272	80541	60668	79494	62046	78424	63406	77329	39
22	57881	81546	59295	80524	60691	79477	62069	78405	63428	77310	38
23	57904	81530	59318	80507	60714	79459	62092	78387	63451	77292	37
24	57928	81513	59342	80489	60738	79441	62115	78369	63473	77273	36
25	57952	81496	59365	80472	60761	79424	62138	78351	63496	77255	35
26	57976	81479	59389	80455	60784	79406	62160	78333	63518	77236	34
27	57999	81462	59412	80438	60807	79388	62183	78315	63540	77218	33
28	58023	81445	59436	80420	60830	79371	62206	78297	63563	77199	32
29	58047	81428	59459	80403	60853	79353	62229	78279	63585	77181	31
30	58070	81412	59482	80386	60876	79335	62251	78261	63608	77162	30
31	58094	81395	59506	80368	60899	79318	62274	78243	63630	77144	29
32	58118	81378	59529	80351	60922	79300	62297	78225	63653	77125	28
33	58141	81361	59552	80334	60945	79282	62320	78206	63675	77107	27
34	58165	81314	59576	80316	60968	79264	62342	78188	63698	77088	26
35	58189	81327	59599	80299	60991	79247	62365	78170	63720	77070	25
36	58212	81310	59622	80282	61015	79229	62388	78152	63742	77051	24
37	58236	81293	59646	80264	61038	79211	62411	78134	63765	77033	23
38	58260	81276	59669	80247	61061	79193	62433	78116	63787	77014	22
39	58283	81259	59693	80230	61084	79176	62456	78098	63810	76996	21
40	58307	81242	59716	80212	61107	79158	62479	78079	63832	76977	20
41	58330	81225	59739	80195	61130	79140	62502	78061	63854	76959	19
42	58354	81208	59763	80178	61153	79122	62524	78043	63877	76940	18
43	58378	81191	59786	80160	61176	79105	62547	78025	63899	76921	17
44	58401	81174	59809	80143	61199	79087	62570	78007	63922	76903	16
45	58425	81157	59832	80125	61222	79069	62592	77988	63944	76884	15
46	58449	81140	59856	80108	61245	79051	62615	77970	63966	76866	14
47	58472	81123	59879	80091	61268	79033	62638	77952	63989	76847	13
48	58496	81106	59902	80073	61291	79015	62660	77934	64011	76828	12
49	58519	81089	59926	80056	61314	78998	62683	77916	64033	76810	11
50	58543	81072	59949	80038	61337	78980	62706	77897	64056	76791	10
51	58567	81055	59972	80021	61360	78962	62728	77879	64078	76772	9
52	58590	81038	59995	80003	61383	78944	62751	77861	64100	76754	8
53	58614	81021	60019	79986	61406	78926	62774	77843	64123	76735	7
54	58637	81004	60042	79968	61429	78908	62796	77824	64145	76717	6
55	58661	80987	60065	79951	61451	78891	62819	77806	64167	76698	5
56	58684	80970	60089	79934	61474	78873	62842	77788	64190	76679	4
57	58708	80953	60112	79916	61497	78855	62864	77769	64212	76661	3
58	58731	80936	60135	79899	61520	78837	62887	77751	64234	76642	2
59	58755	80919	60158	79881	61543	78819	62909	77733	64256	76623	1
M	54 Deg. N. CS.	54 Deg. N. S.	53 Deg. N. CS.	53 Deg. N. S.	52 Deg. N. CS.	52 Deg. N. S.	51 Deg. N. CS.	51 Deg. N. S.	50 Deg. N. CS.	50 Deg. N. S.	M

	40 Deg.		41 Deg.		42 Deg.		43 Deg.		44 Deg.		
M	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	M
0	64279	76604	65606	75471	66913	74314	68200	73135	69466	71934	60
1	64301	76586	65628	75452	66935	74295	68221	73116	69487	71914	59
2	64323	76567	65650	75433	66956	74276	68242	73096	69508	71894	58
3	64346	76548	65672	75414	66978	74256	68264	73076	69529	71873	57
4	64368	76530	65694	75395	66999	74237	68285	73056	69549	71853	56
5	64390	76511	65716	75375	67021	74217	68306	73036	69570	71833	55
6	64412	76492	65738	75356	67043	74198	68327	73016	69591	71813	54
7	64435	76473	65759	75337	67064	74178	68349	72996	69612	71792	53
8	64457	76455	65781	75318	67086	74159	68370	72976	69633	71772	52
9	64479	76436	65803	75299	67107	74139	68391	72957	69654	71752	51
10	64501	76417	65825	75280	67129	74120	68412	72937	69675	71732	50
11	64524	76398	65847	75261	67151	74100	68433	72917	69696	71711	49
12	64546	76380	65869	75241	67172	74080	68455	72897	69717	71691	48
13	64568	76361	65891	75222	67194	74061	68476	72877	69737	71671	47
14	64590	76342	65913	75203	67215	74041	68497	72857	69758	71650	46
15	64612	76323	65935	75184	67237	74022	68518	72837	69779	71630	45
16	64635	76304	65956	75165	67258	74002	68539	72817	69800	71610	44
17	64657	76286	65978	75146	67280	73983	68561	72797	69821	71590	43
18	64679	76267	66000	75126	67301	73963	68582	72777	69842	71569	42
19	64701	76248	66022	75107	67323	73944	68603	72757	69862	71549	41
20	64723	76229	66044	75088	67344	73924	68624	72737	69883	71529	40
21	64746	76210	66066	75069	67366	73904	68645	72717	69904	71508	39
22	64768	76192	66088	75050	67387	73885	68666	72697	69925	71488	38
23	64790	76173	66109	75030	67409	73865	68688	72677	69946	71468	37
24	64812	76154	66131	75011	67430	73846	68709	72657	69966	71447	36
25	64834	76135	66153	74992	67452	73826	68730	72637	69987	71427	35
26	64856	76116	66175	74973	67473	73806	68751	72617	70008	71407	34
27	64878	76097	66197	74953	67495	73787	68772	72597	70029	71386	33
28	64901	76078	66218	74934	67516	73767	68793	72577	70049	71366	32
29	64923	76059	66240	74915	67538	73747	68814	72557	70070	71345	31
30	64945	76041	66262	74896	67559	73728	68835	72537	70091	71325	30
31	64967	76022	66284	74876	67580	73708	68857	72517	70112	71305	29
32	64989	76003	66306	74857	67602	73688	68878	72497	70132	71284	28
33	65011	75984	66327	74838	67623	73669	68899	72477	70153	71264	27
34	65033	75965	66349	74818	67645	73649	68920	72457	70174	71243	26
35	65055	75946	66371	74799	67666	73629	68941	72437	70195	71223	25
36	65077	75927	66393	74780	67688	73610	68962	72417	70215	71203	24
37	65099	75908	66414	74760	67709	73590	68983	72397	70236	71182	23
38	65122	75889	66436	74741	67730	73570	69004	72377	70257	71162	22
39	65144	75870	66458	74722	67752	73551	69025	72357	70277	71141	21
40	65166	75851	66480	74703	67773	73531	69046	72337	70298	71121	20
41	65188	75832	66501	74683	67795	73511	69067	72317	70319	71100	19
42	65210	75813	66523	74664	67816	73491	69088	72297	70339	71080	18
43	65232	75794	66545	74644	67837	73472	69109	72277	70360	71059	17
44	65254	75775	66566	74625	67859	73452	69130	72257	70381	71039	16
45	65276	75756	66588	74606	67880	73432	69151	72236	70401	71019	15
46	65298	75738	66610	74586	67901	73412	69172	72216	70422	70998	14
47	65320	75719	66632	74567	67923	73393	69193	72196	70443	70978	13
48	65342	75699	66653	74548	67944	73373	69214	72176	70463	70957	12
49	65364	75680	66675	74528	67965	73353	69235	72156	70484	70937	11
50	65386	75661	66697	74509	67987	73333	69256	72136	70505	70916	10
51	65408	75642	66718	74489	68008	73314	69277	72116	70525	70896	9
52	65430	75623	66740	74470	68029	73294	69298	72095	70546	70875	8
53	65452	75604	66762	74451	68051	73274	69319	72075	70567	70855	7
54	65474	75585	66783	74431	68072	73254	69340	72055	70587	70834	6
55	65496	75566	66805	74412	68093	73234	69361	72035	70608	70813	5
56	65518	75547	66827	74392	68115	73215	69382	72015	70628	70793	4
57	65540	75528	66848	74373	68136	73195	69403	71995	70649	70772	3
58	65562	75509	66870	74353	68157	73175	69424	71974	70670	70752	2
59	65584	75490	66891	74334	68179	73155	69445	71954	70690	70731	1
60	65606	75471	66913	74314	68200	73135	69466	71934	70711	70711	0
M	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	N. CS.	N. S.	M
	49 Deg.		48 Deg.		47 Deg.		46 Deg.		45 Deg.		

A TRAVERSE TABLE,

SHOWING THE DIFFERENCE OF

LATITUDE AND DEPARTURE

FOR DISTANCES BETWEEN 1 AND 100, AND FOR ANGLES TO QUARTER DEGREES BETWEEN 1° AND 90°.

Distance.	¼ Deg.		½ Deg.		¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.00	1.00	0.01	1.00	0.01	1
2	2.00	0.01	2.00	0.02	2.00	0.03	2
3	3.00	0.01	3.00	0.03	3.00	0.04	3
4	4.00	0.02	4.00	0.03	4.00	0.05	4
5	5.00	0.02	5.00	0.04	5.00	0.07	5
6	6.00	0.03	6.00	0.05	6.00	0.08	6
7	7.00	0.03	7.00	0.06	7.00	0.09	7
8	8.00	0.03	8.00	0.07	8.00	0.10	8
9	9.00	0.04	9.00	0.08	9.00	0.12	9
10	10.00	0.04	10.00	0.09	10.00	0.13	10
11	11.00	0.05	11.00	0.10	11.00	0.14	11
12	12.00	0.05	12.00	0.10	12.00	0.16	12
13	13.00	0.06	13.00	0.11	13.00	0.17	13
14	14.00	0.06	14.00	0.12	14.00	0.18	14
15	15.00	0.07	15.00	0.13	15.00	0.20	15
16	16.00	0.07	16.00	0.14	16.00	0.21	16
17	17.00	0.07	17.00	0.15	17.00	0.22	17
18	18.00	0.08	18.00	0.16	18.00	0.24	18
19	19.00	0.08	19.00	0.17	19.00	0.25	19
20	20.00	0.09	20.00	0.17	20.00	0.26	20
21	21.00	0.09	21.00	0.18	21.00	0.27	21
22	22.00	0.10	22.00	0.19	22.00	0.29	22
23	23.00	0.10	23.00	0.20	23.00	0.30	23
24	24.00	0.10	24.00	0.21	24.00	0.31	24
25	25.00	0.11	25.00	0.22	25.00	0.33	25
26	26.00	0.11	26.00	0.23	26.00	0.34	26
27	27.00	0.12	27.00	0.24	27.00	0.35	27
28	28.00	0.12	28.00	0.24	28.00	0.37	28
29	29.00	0.13	29.00	0.25	29.00	0.38	29
30	30.00	0.13	30.00	0.26	30.00	0.39	30
31	31.00	0.14	31.00	0.27	31.00	0.41	31
32	32.00	0.14	32.00	0.28	32.00	0.42	32
33	33.00	0.14	33.00	0.29	33.00	0.43	33
34	34.00	0.15	34.00	0.30	34.00	0.45	34
35	35.00	0.15	35.00	0.31	35.00	0.46	35
36	36.00	0.16	36.00	0.31	36.00	0.47	36
37	37.00	0.16	37.00	0.32	37.00	0.48	37
38	38.00	0.17	38.00	0.33	38.00	0.50	38
39	39.00	0.17	39.00	0.34	39.00	0.51	39
40	40.00	0.17	40.00	0.35	40.00	0.52	40
41	41.00	0.18	41.00	0.36	41.00	0.54	41
42	42.00	0.18	42.00	0.37	42.00	0.55	42
43	43.00	0.19	43.00	0.38	43.00	0.56	43
44	44.00	0.19	44.00	0.38	44.00	0.58	44
45	45.00	0.20	45.00	0.39	45.00	0.59	45
46	46.00	0.20	46.00	0.40	46.00	0.60	46
47	47.00	0.21	47.00	0.41	47.00	0.62	47
48	48.00	0.21	48.00	0.42	48.00	0.63	48
49	49.00	0.21	49.00	0.43	49.00	0.64	49
50	50.00	0.22	50.00	0.44	50.00	0.65	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89¾ Deg.		89½ Deg.		89¼ Deg.		

Distance.	¼ Deg.		½ Deg.		¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	51.00	0.22	51.00	0.45	51.00	0.67	51
52	52.00	0.23	52.00	0.45	52.00	0.68	52
53	53.00	0.23	53.00	0.46	53.00	0.69	53
54	54.00	0.24	54.00	0.47	54.00	0.71	54
55	55.00	0.24	55.00	0.48	55.00	0.72	55
56	56.00	0.24	56.00	0.49	56.00	0.73	56
57	57.00	0.25	57.00	0.50	57.00	0.75	57
58	58.00	0.25	58.00	0.51	57.99	0.76	58
59	59.00	0.26	59.00	0.51	58.99	0.77	59
60	60.00	0.26	60.00	0.52	59.99	0.79	60
61	61.00	0.27	61.00	0.53	60.99	0.80	61
62	62.00	0.27	62.00	0.54	61.99	0.81	62
63	63.00	0.27	63.00	0.55	62.99	0.82	63
64	64.00	0.28	64.00	0.56	63.99	0.84	64
65	65.00	0.28	65.00	0.57	64.99	0.85	65
66	66.00	0.29	66.00	0.58	65.99	0.86	66
67	67.00	0.29	67.00	0.58	66.99	0.88	67
68	68.00	0.30	68.00	0.59	67.99	0.89	68
69	69.00	0.30	69.00	0.60	68.99	0.90	69
70	70.00	0.31	70.00	0.61	69.99	0.92	70
71	71.00	0.31	71.00	0.62	70.99	0.93	71
72	72.00	0.31	72.00	0.63	71.99	0.94	72
73	73.00	0.32	73.00	0.64	72.99	0.96	73
74	74.00	0.32	74.00	0.65	73.99	0.97	74
75	75.00	0.33	75.00	0.65	74.99	0.98	75
76	76.00	0.33	76.00	0.66	75.99	0.99	76
77	77.00	0.34	77.00	0.67	76.99	1.01	77
78	78.00	0.34	78.00	0.68	77.99	1.02	78
79	79.00	0.34	79.00	0.69	78.99	1.03	79
80	80.00	0.35	80.00	0.70	79.99	1.05	80
81	81.00	0.35	81.00	0.71	80.99	1.06	81
82	82.00	0.36	82.00	0.72	81.99	1.07	82
83	83.00	0.36	83.00	0.72	82.99	1.09	83
84	84.00	0.37	84.00	0.73	83.99	1.10	84
85	85.00	0.37	85.00	0.74	84.99	1.11	85
86	86.00	0.38	86.00	0.75	85.99	1.13	86
87	87.00	0.38	87.00	0.76	86.99	1.14	87
88	88.00	0.38	88.00	0.77	87.99	1.15	88
89	89.00	0.39	89.00	0.78	88.99	1.16	89
90	90.00	0.39	90.00	0.79	89.99	1.18	90
91	91.00	0.40	91.00	0.79	90.99	1.19	91
92	92.00	0.40	92.00	0.80	91.99	1.20	92
93	93.00	0.41	93.00	0.81	92.99	1.22	93
94	94.00	0.41	94.00	0.82	93.99	1.23	94
95	95.00	0.41	95.00	0.83	94.99	1.24	95
96	96.00	0.42	96.00	0.84	95.99	1.26	96
97	97.00	0.42	97.00	0.85	96.99	1.27	97
98	98.00	0.43	98.00	0.86	97.99	1.28	98
99	99.00	0.43	99.00	0.86	98.99	1.30	99
100	100.00	0.44	100.00	0.87	99.99	1.31	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89¾ Deg.		89½ Deg.		89¼ Deg.		

Distance.	1 Deg. Lat.	1 Deg. Dep.	1¼ Deg. Lat.	1¼ Deg. Dep.	1½ Deg. Lat.	1½ Deg. Dep.	1¾ Deg. Lat.	1¾ Deg. Dep.	Distance.
1	1.00	0.02	1.00	0.02	1.00	0.03	1.00	0.03	1
2	2.00	0.03	2.00	0.04	2.00	0.05	2.00	0.06	2
3	3.00	0.05	3.00	0.07	3.00	0.08	3.00	0.09	3
4	4.00	0.07	4.00	0.09	4.00	0.10	4.00	0.12	4
5	5.00	0.09	5.00	0.11	5.00	0.13	5.00	0.15	5
6	6.00	0.10	6.00	0.13	6.00	0.16	6.00	0.18	6
7	7.00	0.12	7.00	0.15	7.00	0.18	7.00	0.21	7
8	8.00	0.14	8.00	0.17	8.00	0.21	8.00	0.25	8
9	9.00	0.16	9.00	0.20	9.00	0.24	9.00	0.28	9
10	10.00	0.17	10.00	0.22	10.00	0.26	10.00	0.31	10
11	11.00	0.19	11.00	0.24	11.00	0.28	10.99	0.34	11
12	12.00	0.21	12.00	0.26	12.00	0.31	11.99	0.37	12
13	13.00	0.23	13.00	0.28	13.00	0.34	12.99	0.40	13
14	14.00	0.24	14.00	0.31	14.00	0.37	13.99	0.43	14
15	15.00	0.26	15.00	0.33	14.99	0.39	14.99	0.46	15
16	16.00	0.28	16.00	0.35	15.99	0.42	15.99	0.49	16
17	17.00	0.30	17.00	0.37	16.99	0.45	16.99	0.52	17
18	18.00	0.31	18.00	0.39	17.99	0.47	17.99	0.55	18
19	19.00	0.33	19.00	0.41	18.99	0.50	18.99	0.58	19
20	20.00	0.35	20.00	0.44	19.99	0.52	19.99	0.61	20
21	21.00	0.37	21.00	0.46	20.99	0.55	20.99	0.64	21
22	22.00	0.38	21.99	0.48	21.99	0.58	21.99	0.67	22
23	23.00	0.40	22.99	0.50	22.99	0.60	22.99	0.70	23
24	24.00	0.42	23.99	0.52	23.99	0.63	23.99	0.73	24
25	25.00	0.44	24.99	0.55	24.99	0.65	24.99	0.76	25
26	26.00	0.45	25.99	0.57	25.99	0.68	25.99	0.79	26
27	27.00	0.47	26.99	0.59	26.99	0.71	26.99	0.83	27
28	28.00	0.49	27.99	0.61	27.99	0.73	27.99	0.86	28
29	29.00	0.51	28.99	0.63	28.99	0.76	28.99	0.89	29
30	30.00	0.52	29.99	0.65	29.99	0.79	29.99	0.92	30
31	31.00	0.54	30.99	0.68	30.99	0.81	30.99	0.95	31
32	32.00	0.56	31.99	0.70	31.99	0.84	31.99	0.98	32
33	32.99	0.58	32.99	0.72	32.99	0.86	32.98	1.01	33
34	33.99	0.59	33.99	0.74	33.99	0.89	33.98	1.04	34
35	34.99	0.61	34.99	0.76	34.99	0.92	34.98	1.07	35
36	35.99	0.63	35.99	0.79	35.99	0.94	35.98	1.10	36
37	36.99	0.65	36.99	0.81	36.99	0.97	36.98	1.13	37
38	37.99	0.66	37.99	0.83	37.99	0.99	37.98	1.16	38
39	38.99	0.68	38.99	0.85	38.99	1.02	38.98	1.19	39
40	39.99	0.70	39.99	0.87	39.99	1.05	39.98	1.22	40
41	40.99	0.72	40.99	0.89	40.99	1.07	40.98	1.25	41
42	41.99	0.73	41.99	0.92	41.99	1.10	41.98	1.28	42
43	42.99	0.75	42.99	0.94	42.99	1.13	42.98	1.31	43
44	43.99	0.77	43.99	0.96	43.99	1.15	43.98	1.34	44
45	44.99	0.79	44.99	0.98	44.99	1.18	44.98	1.37	45
46	45.99	0.80	45.99	1.00	45.99	1.20	45.98	1.40	46
47	46.99	0.82	46.99	1.03	46.99	1.23	46.98	1.44	47
48	47.99	0.84	47.99	1.05	47.98	1.26	47.98	1.47	48
49	48.99	0.86	48.99	1.07	48.98	1.28	48.98	1.50	49
50	49.99	0.87	49.99	1.09	49.98	1.31	49.98	1.53	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89 Deg.		88¾ Deg.		88½ Deg.		88¼ Deg.		

Distance.	1 Deg.		1¼ Deg.		1½ Deg.		1¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.99	0.89	50.99	1.11	50.98	1.34	50.98	1.56	51
52	51.99	0.91	51.99	1.13	51.98	1.36	51.98	1.59	52
53	52.99	0.92	52.99	1.16	52.98	1.39	52.98	1.62	53
54	53.99	0.94	53.99	1.18	53.98	1.41	53.97	1.65	54
55	54.99	0.96	54.99	1.20	54.98	1.44	54.97	1.68	55
56	55.99	0.98	55.99	1.22	55.98	1.47	55.97	1.71	56
57	56.99	0.99	56.99	1.24	56.98	1.49	56.97	1.74	57
58	57.99	1.01	57.90	1.27	57.98	1.52	57.97	1.77	58
59	58.99	1.03	58.99	1.29	58.98	1.54	58.97	1.80	59
60	59.99	1.05	59.99	1.31	59.98	1.57	59.97	1.83	60
61	60.99	1.06	60.99	1.33	60.98	1.60	60.97	1.86	61
62	61.99	1.08	61.99	1.35	61.98	1.62	61.97	1.89	62
63	62.99	1.10	62.99	1.37	62.98	1.65	62.97	1.92	63
64	63.90	1.12	63.98	1.40	63.98	1.68	63.97	1.95	64
65	64.99	1.13	64.98	1.42	64.98	1.70	64.97	1.99	65
66	65.99	1.15	65.98	1.44	65.98	1.73	65.97	2.02	66
67	66.99	1.17	66.98	1.46	66.98	1.75	66.97	2.05	67
68	67.99	1.19	67.98	1.48	67.98	1.78	67.97	2.08	68
69	68.99	1.20	68.98	1.51	68.98	1.81	68.97	2.11	69
70	69.99	1.22	69.98	1.53	69.98	1.83	69.97	2.14	70
71	70.99	1.24	70.98	1.55	70.98	1.86	70.97	2.17	71
72	71.99	1.26	71.98	1.57	71.98	1.88	71.97	2.20	72
73	72.99	1.27	72.98	1.59	72.97	1.91	72.97	2.23	73
74	73.99	1.29	73.98	1.61	73.97	1.94	73.97	2.26	74
75	74.99	1.31	74.98	1.64	74.97	1.96	74.97	2.29	75
76	75.99	1.33	75.98	1.66	75.97	1.99	75.96	2.32	76
77	76.99	1.34	76.98	1.68	76.97	2.02	76.96	2.35	77
78	77.99	1.36	77.98	1.70	77.97	2.04	77.96	2.38	78
79	78.99	1.38	78.98	1.72	78.97	2.07	78.96	2.41	79
80	79.99	1.40	79.98	1.75	79.97	2.09	79.96	2.44	80
81	80.99	1.41	80.98	1.77	80.97	2.12	80.96	2.47	81
82	81.99	1.43	81.98	1.79	81.97	2.15	81.96	2.50	82
83	82.99	1.45	82.98	1.81	82.97	2.17	82.96	2.53	83
84	83.99	1.47	83.98	1.83	83.97	2.20	83.96	2.57	84
85	84.99	1.48	84.98	1.85	84.97	2.23	84.96	2.60	85
86	85.99	1.50	85.98	1.88	85.97	2.25	85.96	2.63	86
87	86.99	1.52	86.98	1.90	86.97	2.28	86.96	2.66	87
88	87.99	1.54	87.98	1.92	87.97	2.30	87.96	2.69	88
89	88.99	1.55	88.98	1.94	88.97	2.33	88.96	2.72	89
90	89.99	1.57	89.98	1.96	89.97	2.36	89.96	2.75	90
91	90.99	1.59	90.98	1.99	90.97	2.38	90.96	2.78	91
92	91.99	1.61	91.98	2.01	91.97	2.41	91.96	2.81	92
93	92.99	1.62	92.98	2.03	92.97	2.43	92.96	2.84	93
94	93.99	1.64	93.98	2.05	93.97	2.46	93.96	2.87	94
95	94.99	1.66	94.98	2.07	94.97	2.49	94.96	2.90	95
96	95.99	1.68	95.98	2.09	95.97	2.51	95.96	2.94	96
97	96.99	1.69	96.98	2.12	96.97	2.54	96.95	2.96	97
98	97.99	1.71	97.98	2.14	97.97	2.57	97.95	2.99	98
99	98.98	1.73	98.98	2.16	98.97	2.59	98.95	3.02	99
100	99.98	1.75	99.98	2.18	99.97	2.62	99.95	3.05	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89 Deg.		88¾ Deg.		88½ Deg.		88¼ Deg.		

Distance.	2 Deg.		2¼ Deg.		2½ Deg.		2¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.03	1.00	0.04	1.00	0.04	1.00	0.05	1
2	2.00	0.07	2.00	0.08	2.00	0.09	2.00	0.10	2
3	3.00	0.10	3.00	0.12	3.00	0.13	3.00	0.14	3
4	4.00	0.14	4.00	0.16	4.00	0.17	4.00	0.19	4
5	5.00	0.17	5.00	0.20	5.00	0.22	4.99	0.24	5
6	6.00	0.21	6.00	0.24	5.99	0.26	5.99	0.29	6
7	7.00	0.24	6.99	0.27	6.99	0.31	6.99	0.34	7
8	7.99	0.28	7.99	0.31	7.99	0.35	7.99	0.38	8
9	8.99	0.31	8.99	0.35	8.99	0.39	8.99	0.43	9
10	9.99	0.35	9.99	0.39	9.99	0.44	9.99	0.48	10
11	10.99	0.38	10.99	0.43	10.99	0.48	10.99	0.53	11
12	11.99	0.42	11.99	0.47	11.99	0.52	11.99	0.58	12
13	12.99	0.45	12.99	0.51	12.99	0.57	12.99	0.62	13
14	13.99	0.49	13.99	0.55	13.99	0.61	13.98	0.67	14
15	14.99	0.52	14.99	0.59	14.99	0.65	14.98	0.72	15
16	15.99	0.56	15.99	0.63	15.99	0.70	15.98	0.77	16
17	16.99	0.59	16.99	0.67	16.98	0.74	16.98	0.82	17
18	17.99	0.63	17.99	0.71	17.98	0.79	17.98	0.86	18
19	18.99	0.66	18.99	0.75	18.98	0.83	18.98	0.91	19
20	19.99	0.70	19.98	0.79	19.98	0.87	19.98	0.96	20
21	20.99	0.73	20.98	0.82	20.98	0.92	20.98	1.01	21
22	21.99	0.77	21.98	0.86	21.98	0.96	21.97	1.06	22
23	22.99	0.80	22.98	0.90	22.98	1.00	22.97	1.10	23
24	23.99	0.84	23.98	0.94	23.98	1.05	23.97	1.15	24
25	24.98	0.87	24.98	0.98	24.98	1.09	24.97	1.20	25
26	25.98	0.91	25.98	1.02	25.98	1.13	25.97	1.25	26
27	26.98	0.94	26.98	1.06	26.97	1.18	26.97	1.30	27
28	27.98	0.98	27.98	1.10	27.97	1.22	27.97	1.34	28
29	28.98	1.01	28.98	1.14	28.97	1.26	28.97	1.39	29
30	29.98	1.05	29.98	1.18	29.97	1.31	29.97	1.44	30
31	30.98	1.08	30.98	1.22	30.97	1.35	30.96	1.49	31
32	31.98	1.12	31.98	1.26	31.97	1.40	31.96	1.54	32
33	32.98	1.15	32.97	1.30	32.97	1.44	32.96	1.58	33
34	33.98	1.19	33.97	1.33	33.97	1.48	33.96	1.63	34
35	34.98	1.22	34.97	1.37	34.97	1.53	34.96	1.68	35
36	35.98	1.26	35.97	1.41	35.97	1.57	35.96	1.73	36
37	36.98	1.29	36.97	1.45	36.96	1.61	36.96	1.78	37
38	37.98	1.33	37.97	1.49	37.96	1.66	37.96	1.82	38
39	38.98	1.36	38.97	1.53	38.96	1.70	38.96	1.87	39
40	39.98	1.40	39.97	1.57	39.96	1.75	39.95	1.92	40
41	40.98	1.43	40.97	1.61	40.96	1.77	40.95	1.97	41
42	41.97	1.47	41.97	1.65	41.96	1.83	41.95	2.02	42
43	42.97	1.50	42.97	1.69	42.96	1.88	42.95	2.06	43
44	43.97	1.54	43.97	1.73	43.96	1.92	43.95	2.11	44
45	44.97	1.57	44.97	1.77	44.96	1.96	44.95	2.16	45
46	45.97	1.61	45.96	1.81	45.96	2.01	45.95	2.21	46
47	46.97	1.64	46.96	1.85	46.96	2.05	46.95	2.25	47
48	47.97	1.68	47.96	1.88	47.95	2.09	47.95	2.30	48
49	48.97	1.71	48.96	1.92	48.95	2.14	48.94	2.35	49
50	49.97	1.74	49.96	1.96	49.95	2.18	49.94	2.40	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	88 Deg.		87¾ Deg.		87½ Deg.		87¼ Deg.		

Distance.	2 Deg.		2¼ Deg.		2½ Deg.		2¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.97	1.78	50.96	2.00	50.95	2.22	50.94	2.45	51
52	51.97	1.81	51.96	2.04	51.95	2.27	51.94	2.50	52
53	52.97	1.85	52.96	2.08	52.95	2.31	52.94	2.54	53
54	53.97	1.88	53.96	2.12	53.95	2.36	53.94	2.59	54
55	54.97	1.92	54.96	2.16	54.95	2.40	54.94	2.64	55
56	55.97	1.95	55.96	2.20	55.95	2.44	55.94	2.69	56
57	56.97	1.99	56.96	2.24	56.95	2.49	56.93	2.73	57
58	57.96	2.02	57.96	2.28	57.94	2.53	57.93	2.78	58
59	58.96	2.06	58.95	2.32	58.94	2.57	58.93	2.83	59
60	59.96	2.09	59.95	2.36	59.94	2.62	59.93	2.88	60
61	60.96	2.13	60.95	2.39	60.94	2.66	60.93	2.93	61
62	61.96	2.16	61.95	2.43	61.94	2.70	61.93	2.97	62
63	62.96	2.20	62.95	2.47	62.94	2.75	62.93	3.02	63
64	63.96	2.23	63.95	2.51	63.94	2.79	63.93	3.07	64
65	64.96	2.27	64.95	2.55	64.94	2.84	64.93	3.12	65
66	65.96	2.30	65.95	2.59	65.94	2.88	65.92	3.17	66
67	66.96	2.34	66.95	2.63	66.94	2.92	66.92	3.21	67
68	67.96	2.37	67.95	2.67	67.94	2.97	67.92	3.26	68
69	68.96	2.41	68.95	2.71	68.93	3.01	68.92	3.31	69
70	69.96	2.44	69.95	2.75	69.93	3.05	69.92	3.36	70
71	70.96	2.48	70.95	2.79	70.93	3.10	70.92	3.41	71
72	71.96	2.51	71.94	2.83	71.93	3.14	71.92	3.45	72
73	72.96	2.55	72.94	2.87	72.93	3.18	72.92	3.50	73
74	73.95	2.58	73.94	2.91	73.93	3.23	73.91	3.55	74
75	74.95	2.62	74.94	2.94	74.93	3.27	74.91	3.60	75
76	75.95	2.65	75.94	2.98	75.93	3.31	75.91	3.65	76
77	76.95	2.69	76.94	3.02	76.93	3.36	76.91	3.70	77
78	77.95	2.72	77.94	3.06	77.93	3.40	77.91	3.74	78
79	78.95	2.76	78.94	3.10	78.92	3.45	78.91	3.79	79
80	79.95	2.79	79.94	3.14	79.92	3.49	79.91	3.84	80
81	80.95	2.83	80.94	3.18	80.92	3.53	80.91	3.89	81
82	81.95	2.86	81.94	3.22	81.92	3.58	81.91	3.93	82
83	82.95	2.90	82.94	3.26	82.92	3.62	82.90	3.98	83
84	83.95	2.93	83.94	3.30	83.92	3.66	83.90	4.03	84
85	84.95	2.97	84.93	3.34	84.92	3.71	84.90	4.08	85
86	85.95	3.00	85.93	3.38	85.92	3.75	85.90	4.13	86
87	86.95	3.04	86.93	3.42	86.92	3.79	86.90	4.17	87
88	87.95	3.07	87.93	3.45	87.92	3.84	87.90	4.22	88
89	88.95	3.11	88.93	3.49	88.92	3.88	88.90	4.27	89
90	89.95	3.14	89.93	3.53	89.91	3.93	89.90	4.32	90
91	90.95	3.18	90.93	3.57	90.91	3.97	90.90	4.37	91
92	91.94	3.21	91.93	3.61	91.91	4.01	91.89	4.41	92
93	92.94	3.25	92.93	3.65	92.91	4.06	92.89	4.46	93
94	93.94	3.28	93.93	3.69	93.91	4.10	93.89	4.51	94
95	94.94	3.32	94.93	3.73	94.91	4.14	94.89	4.56	95
96	95.94	3.35	95.93	3.77	95.91	4.19	95.89	4.61	96
97	96.94	3.39	96.93	3.81	96.91	4.23	96.89	4.65	97
98	97.94	3.42	97.92	3.85	97.91	4.27	97.89	4.70	98
99	98.94	3.46	98.92	3.89	98.91	4.32	98.89	4.75	99
100	99.94	3.49	99.92	3.93	99.91	4.36	99.88	4.80	100
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance.	88 Deg.		87¾ Deg.		87½ Deg.		87¼ Deg.		Distance.

Distance.	3 Deg.		3¼ Deg.		3½ Deg.		3¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.05	1.00	0.06	1.00	0.06	1.00	0.06	1
2	2.00	0.10	2.00	0.11	2.00	0.12	2.00	0.13	2
3	3.00	0.16	3.00	0.17	2.99	0.18	2.99	0.20	3
4	3.99	0.21	3.99	0.23	3.99	0.24	3.99	0.26	4
5	4.99	0.26	4.99	0.28	4.99	0.31	4.99	0.33	5
6	5.99	0.31	5.99	0.34	5.99	0.37	5.99	0.39	6
7	6.99	0.37	6.99	0.40	6.99	0.43	6.99	0.46	7
8	7.99	0.42	7.99	0.45	7.99	0.49	7.98	0.52	8
9	8.99	0.47	8.99	0.51	8.98	0.55	8.98	0.59	9
10	9.99	0.52	9.98	0.57	9.98	0.61	9.98	0.65	10
11	10.98	0.58	10.98	0.62	10.98	0.67	10.98	0.72	11
12	11.98	0.63	11.98	0.68	11.98	0.73	11.97	0.78	12
13	12.98	0.68	12.98	0.73	12.98	0.79	12.97	0.85	13
14	13.98	0.73	13.98	0.79	13.97	0.85	13.97	0.92	14
15	14.98	0.79	14.98	0.85	14.97	0.92	14.97	0.98	15
16	15.98	0.84	15.97	0.91	15.97	0.98	15.97	1.05	16
17	16.98	0.89	16.97	0.96	16.97	1.04	16.96	1.11	17
18	17.98	0.94	17.97	1.02	17.97	1.10	17.96	1.18	18
19	18.98	0.99	18.97	1.08	18.96	1.16	18.96	1.24	19
20	19.97	1.05	19.97	1.13	19.96	1.22	19.96	1.31	20
21	20.97	1.10	20.97	1.19	20.96	1.28	20.96	1.37	21
22	21.97	1.15	21.96	1.25	21.96	1.31	21.95	1.44	22
23	22.97	1.20	22.96	1.30	22.96	1.40	22.95	1.50	23
24	23.97	1.26	23.96	1.36	23.96	1.47	23.95	1.57	24
25	24.97	1.31	24.96	1.42	24.95	1.53	24.95	1.61	25
26	25.96	1.36	25.96	1.47	25.95	1.59	25.94	1.70	26
27	26.96	1.41	26.96	1.53	26.95	1.65	26.94	1.77	27
28	27.96	1.47	27.95	1.59	27.95	1.71	27.94	1.83	28
29	28.96	1.52	28.95	1.64	28.95	1.77	28.94	1.90	29
30	29.96	1.57	29.95	1.70	29.94	1.83	29.94	1.96	30
31	30.96	1.62	30.95	1.76	30.94	1.89	30.93	2.03	31
32	31.96	1.67	31.95	1.81	31.94	1.95	31.93	2.09	32
33	32.95	1.73	32.95	1.87	32.94	2.01	32.93	2.16	33
34	33.95	1.78	33.95	1.93	33.94	2.08	33.93	2.22	34
35	34.95	1.83	34.94	1.98	34.93	2.14	34.92	2.29	35
36	35.95	1.88	35.94	2.04	35.93	2.20	35.92	2.35	36
37	36.95	1.94	36.94	2.10	36.93	2.25	36.92	2.42	37
38	37.95	1.99	37.94	2.15	37.93	2.32	37.92	2.49	38
39	38.95	2.04	38.94	2.21	38.93	2.38	38.92	2.55	39
40	39.95	2.09	39.94	2.27	39.93	2.44	39.91	2.62	40
41	40.94	2.15	40.93	2.32	40.92	2.50	40.91	2.68	41
42	41.94	2.20	41.93	2.38	41.92	2.56	41.91	2.75	42
43	42.94	2.25	42.93	2.44	42.92	2.63	42.91	2.81	43
44	43.94	2.30	43.93	2.49	43.92	2.69	43.91	2.88	44
45	44.94	2.36	44.93	2.55	44.92	2.75	44.90	2.94	45
46	45.94	2.41	45.93	2.61	45.91	2.81	45.90	3.01	46
47	46.94	2.46	46.92	2.66	46.91	2.87	46.90	3.07	47
48	47.93	2.51	47.92	2.72	47.91	2.93	47.90	3.14	48
49	48.93	2.56	48.92	2.78	48.91	2.99	48.90	3.20	49
50	49.93	2.62	49.92	2.83	49.91	3.05	49.89	3.27	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat	Distance.
	87 Deg.		86¾ Deg.		86½ Deg.		86¼ Deg.		

Distance.	3 Deg.		3¼ Deg.		3½ Deg.		3¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.93	2.67	50.92	2.89	50.90	3.11	50.89	3.34	51
52	51.93	2.72	51.92	2.95	51.90	3.17	51.89	3.40	52
53	52.93	2.77	52.91	3.00	52.90	3.24	52.89	3.47	53
54	53.93	2.83	53.91	3.06	53.90	3.30	53.88	3.53	54
55	54.92	2.88	54.91	3.12	54.90	3.36	54.88	3.60	55
56	55.92	2.93	55.91	3.17	55.90	3.42	55.88	3.66	56
57	56.92	2.98	56.91	3.23	56.89	3.48	56.88	3.73	57
58	57.92	3.04	57.91	3.29	57.89	3.54	57.88	3.79	58
59	58.92	3.09	58.91	3.34	58.89	3.60	58.87	3.86	59
60	59.92	3.14	59.90	3.40	59.89	3.66	59.87	3.92	60
61	60.92	3.19	60.90	3.46	60.89	3.72	60.87	3.99	61
62	61.92	3.24	61.90	3.51	61.88	3.79	61.87	4.05	62
63	62.91	3.30	62.90	3.57	62.88	3.85	62.87	4.12	63
64	63.91	3.35	63.90	3.63	63.88	3.91	63.86	4.19	64
65	64.91	3.40	64.90	3.69	64.88	3.97	64.86	4.25	65
66	65.91	3.45	65.89	3.74	65.88	4.03	65.86	4.32	66
67	66.91	3.51	66.89	3.80	66.88	4.09	66.86	4.38	67
68	67.91	3.56	67.89	3.85	67.87	4.15	67.85	4.45	68
69	68.91	3.61	68.89	3.91	68.87	4.21	68.85	4.51	69
70	69.90	3.66	69.89	3.97	69.87	4.27	69.85	4.58	70
71	70.90	3.72	70.89	4.02	70.87	4.33	70.85	4.64	71
72	71.90	3.77	71.88	4.08	71.87	4.40	71.85	4.71	72
73	72.90	3.82	72.88	4.14	72.86	4.46	72.84	4.77	73
74	73.90	3.87	73.88	4.20	73.86	4.52	73.84	4.84	74
75	74.90	3.93	74.88	4.25	74.86	4.58	74.84	4.91	75
76	75.90	3.98	75.88	4.31	75.86	4.64	75.84	4.97	76
77	76.89	4.03	76.88	4.37	76.86	4.70	76.84	5.04	77
78	77.89	4.08	77.87	4.42	77.85	4.76	77.83	5.10	78
79	78.89	4.13	78.87	4.48	78.85	4.82	78.83	5.17	79
80	79.89	4.19	79.87	4.54	79.85	4.88	79.83	5.23	80
81	80.89	4.24	80.87	4.59	80.85	4.94	80.83	5.30	81
82	81.89	4.29	81.87	4.65	81.85	5.01	81.82	5.36	82
83	82.89	4.34	82.87	4.71	82.85	5.07	82.82	5.43	83
84	83.88	4.40	83.86	4.76	83.84	5.13	83.82	5.49	84
85	84.88	4.45	84.86	4.82	84.84	5.19	84.82	5.56	85
86	85.88	4.50	85.86	4.88	85.84	5.25	85.82	5.62	86
87	86.88	4.55	86.86	4.93	86.84	5.31	86.81	5.69	87
88	87.88	4.61	87.86	4.99	87.84	5.37	87.81	5.76	88
89	88.88	4.66	88.86	5.05	88.83	5.43	88.81	5.82	89
90	89.88	4.71	89.86	5.10	89.83	5.49	89.81	5.89	90
91	90.88	4.76	90.85	5.16	90.83	5.56	90.81	5.95	91
92	91.87	4.81	91.85	5.22	91.83	5.62	91.80	6.02	92
93	92.87	4.87	92.85	5.27	92.83	5.68	92.80	6.08	93
94	93.87	4.92	93.85	5.33	93.82	5.74	93.80	6.15	94
95	94.87	4.97	94.85	5.39	94.82	5.80	94.80	6.21	95
96	95.87	5.02	95.85	5.44	95.82	5.86	95.79	6.28	96
97	96.87	5.08	96.84	5.50	96.82	5.92	96.79	6.34	97
98	97.87	5.13	97.84	5.56	97.82	5.98	97.79	6.41	98
99	98.86	5.18	98.84	5.61	98.82	6.04	98.79	6.47	99
100	99.86	5.23	99.84	5.67	99.81	6.10	99.79	6.54	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	87 Deg.		86¾ Deg.		86½ Deg.		86¼ Deg.		

Distance.	4 Deg.		4¼ Deg.		4½ Deg.		4¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.07	1.00	0.07	1.00	0.08	1.00	0.08	1
2	2.00	0.14	1.99	0.15	1.99	0.16	1.99	0.17	2
3	2.99	0.21	2.99	0.22	2.99	0.24	2.99	0.25	3
4	3.99	0.28	3.99	0.30	3.99	0.31	3.98	0.33	4
5	4.99	0.35	4.99	0.37	4.98	0.39	4.98	0.41	5
6	5.99	0.42	5.98	0.44	5.98	0.47	5.98	0.50	6
7	6.98	0.49	6.98	0.52	6.98	0.55	6.97	0.58	7
8	7.98	0.56	7.98	0.59	7.98	0.63	7.97	0.66	8
9	8.98	0.63	8.98	0.67	8.97	0.71	8.97	0.75	9
[illegible]	[illegible]	[illegible]	9.97	0.74	9.97	0.78	9.97	0.83	10
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.97	0.86	10.96	0.91	11
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.96	0.94	11.96	0.99	12
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12.96	1.02	12.96	1.08	13
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13.96	1.10	13.95	1.16	14
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14.95	1.18	14.95	1.24	15
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15.95	1.26	15.95	1.32	16
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16.95	1.83	16.94	1.41	17
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17.94	1.41	17.94	1.49	18
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18.94	1.49	18.93	1.57	19
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19.94	1.57	19.93	1.66	20
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20.94	1.65	20.93	1.74	21
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21.93	1.73	21.92	1.82	22
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22.93	1.80	22.92	1.90	23
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23.93	1.88	23.92	1.99	24
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24.92	1.96	24.91	2.07	25
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.04	25.91	2.15	26
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.12	26.91	2.24	27
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.20	27.90	2.32	28
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.28	28.90	2.40	29
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.35	29.90	2.48	30
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.43	30.89	2.57	31
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.51	31.89	2.65	32
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.59	32.89	2.73	33
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.67	33.88	2.82	34
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.75	34.88	2.90	35
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.82	35.88	2.98	36
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.90	36.87	3.06	37
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.98	37.87	3.15	38
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.06	38.87	3.23	39
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.14	39.86	3.31	40
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.22	40.86	3.40	41
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.30	41.86	3,48	42
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.37	42.85	3.56	43
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.45	43.85	3.64	44
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.53	44.85	3.73	45
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.61	45.84	3.81	46
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.69	46.84	3.89	47
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.77	47.84	3.97	48
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.84	48.83	4.06	49
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.92	49.83	4.14	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	[illegible]		[illegible]		85½ Deg.		85¼ Deg.		

Distance.	4 Deg. Lat.	4 Deg. Dep.	4¼ Deg. Lat.	4¼ Deg. Dep.	4½ Deg. Lat.	4½ Deg. Dep.	4¾ Deg. Lat.	4¾ Deg. Dep.	Distance.
51	50.88	3.56	50.86	3.78	50.84	4.00	50.82	4.22	51
52	51.87	3.63	51.86	3.85	51.84	4.08	51.82	4.31	52
53	52.87	3.70	52.85	3.93	52.84	4.16	52.82	4.39	53
54	53.87	3.77	53.85	4.00	53.83	4.24	53.81	4.47	54
55	54.87	3.84	54.85	4.08	54.83	4.32	54.81	4.55	55
56	55.86	3.91	55.85	4.15	55.83	4.39	55.81	4.64	56
57	56.86	3.98	56.84	4.22	56.82	4.47	56.80	4.72	57
58	57.86	4.05	57.84	4.30	57.82	4.55	57.80	4.80	58
59	58.86	4.12	58.84	4.37	58.82	4.63	58.80	4.89	59
60	59.85	4.19	59.84	4.45	59.82	4.71	59.79	4.97	60
61	60.85	4.26	60.83	4.52	60.81	4.79	60.79	5.05	61
62	61.85	4.32	61.83	4.59	61.81	4.86	61.79	5.13	62
63	62.85	4.39	62.83	4.67	62.81	4.94	62.78	5.22	63
64	63.84	4.46	63.82	4.74	63.80	5.02	63.78	5.30	64
65	64.84	4.53	64.82	4.82	64.80	5.10	64.78	5.38	65
66	65.84	4.60	65.82	4.89	65.80	5.18	65.77	5.47	66
67	66.84	4.67	66.82	4.97	66.79	5.26	66.77	5.55	67
68	67.83	4.74	67.81	5.04	67.79	5.34	67.77	5.63	68
69	68.83	4.81	68.81	5.11	68.79	5.41	68.76	5.71	69
70	69.83	4.88	69.81	5.19	69.78	5.49	69.76	5.80	70
71	70.83	4.95	70.80	5.26	70.78	5.57	70.76	5.88	71
72	71.82	5.02	71.80	5.34	71.78	5.65	71.75	5.96	72
73	72.82	5.09	72.80	5.41	72.77	5.73	72.75	6.04	73
74	73.82	5.16	73.80	5.48	73.77	5.81	73.75	6.13	74
75	74.82	5.23	74.79	5.56	74.77	5.88	74.74	6.21	75
76	75.81	5.30	75.79	5.63	75.77	5.96	75.74	6.29	76
77	76.81	5.37	76.79	5.71	76.76	6.04	76.74	6.38	77
78	77.81	5.44	77.79	5.78	77.76	6.12	77.73	6.46	78
79	78.81	5.51	78.78	5.85	78.76	6.20	78.73	6.54	79
80	79.81	5.58	79.78	5.93	79.75	6.28	79.73	6.62	80
81	80.80	5.65	80.78	6.00	80.75	6.36	80.72	6.71	81
82	81.80	5.72	81.78	6.08	81.75	6.43	81.72	6.79	82
83	82.80	5.79	82.77	6.15	82.74	6.51	82.71	6.87	83
84	83.80	5.86	83.77	6.23	83.74	6.59	83.71	6.96	84
85	84.79	5.93	84.77	6.30	84.74	6.67	84.71	7.04	85
86	85.79	6.00	85.76	6.37	85.73	6.75	85.70	7.12	86
87	86.79	6.07	86.76	6.45	86.73	6.83	86.70	7.20	87
88	87.79	6.14	87.76	6.52	87.73	6.90	87.70	7.29	88
89	88.78	6.21	88.76	6.60	88.73	6.98	88.70	7.37	89
90	89.78	6.28	89.75	6.67	89.72	7.06	89.69	7.45	90
91	90.78	6.35	90.75	6.74	90.72	7.14	90.69	7.54	91
92	91.78	6.42	91.75	6.82	91.72	7.22	91.68	7.62	92
93	92.77	6.49	92.74	6.89	92.71	7.30	92.68	7.70	93
94	93.77	6.56	93.74	6.97	93.71	7.38	93.68	7.78	94
95	94.77	6.63	94.74	7.04	94.71	7.45	94.67	7.87	95
96	95.77	6.70	95.74	7.11	95.70	7.53	95.67	7.95	96
97	96.76	6.77	96.73	7.19	96.70	7.61	96.67	8.03	97
98	97.76	6.84	97.73	7.26	97.70	7.69	97.66	8.12	98
99	98.76	6.91	98.73	7.34	98.69	7.77	98.66	8.20	99
100	99.76	6.98	99.73	7.41	99.69	7.85	99.66	8.28	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	86 Deg.		85¾ Deg.		85½ Deg.		85¼ Deg.		

Distance.	¼ Deg.		½ Deg.		¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.00	1.00	0.01	1.00	0.01	1
2	2.00	0.01	2.00	0.02	2.00	0.03	2
3	3.00	0.01	3.00	0.03	3.00	0.04	3
4	4.00	0.02	4.00	0.03	4.00	0.05	4
5	5.00	0.02	5.00	0.04	5.00	0.07	5
6	6.00	0.03	6.00	0.05	6.00	0.08	6
7	7.00	0.03	7.00	0.06	7.00	0.09	7
8	8.00	0.03	8.00	0.07	8.00	0.10	8
9	9.00	0.04	9.00	0.08	9.00	0.12	9
10	10.00	0.04	10.00	0.09	10.00	0.13	10
11	11.00	0.05	11.00	0.10	11.00	0.14	11
12	12.00	0.05	12.00	0.10	12.00	0.16	12
13	13.00	0.06	13.00	0.11	13.00	0.17	13
14	14.00	0.06	14.00	0.12	14.00	0.18	14
15	15.00	0.07	15.00	0.13	15.00	0.20	15
16	16.00	0.07	16.00	0.14	16.00	0.21	16
17	17.00	0.07	17.00	0.15	17.00	0.22	17
18	18.00	0.08	18.00	0.16	18.00	0.24	18
19	19.00	0.08	19.00	0.17	19.00	0.25	19
20	20.00	0.09	20.00	0.17	20.00	0.26	20
21	21.00	0.09	21.00	0.18	21.00	0.27	21
22	22.00	0.10	22.00	0.19	22.00	0.29	22
23	23.00	0.10	23.00	0.20	23.00	0.30	23
24	24.00	0.10	24.00	0.21	24.00	0.31	24
25	25.00	0.11	25.00	0.22	25.00	0.33	25
26	26.00	0.11	26.00	0.23	26.00	0.34	26
27	27.00	0.12	27.00	0.24	27.00	0.35	27
28	28.00	0.12	28.00	0.24	28.00	0.37	28
29	29.00	0.13	29.00	0.25	29.00	0.38	29
30	30.00	0.13	30.00	0.26	30.00	0.39	30
31	31.00	0.14	31.00	0.27	31.00	0.41	31
32	32.00	0.14	32.00	0.28	32.00	0.42	32
33	33.00	0.14	33.00	0.29	33.00	0.43	33
34	34.00	0.15	34.00	0.30	34.00	0.45	34
35	35.00	0.15	35.00	0.31	35.00	0.46	35
36	36.00	0.16	36.00	0.31	36.00	0.47	36
37	37.00	0.16	37.00	0.32	37.00	0.48	37
38	38.00	0.17	38.00	0.33	38.00	0.50	38
39	39.00	0.17	39.00	0.34	39.00	0.51	39
40	40.00	0.17	40.00	0.35	40.00	0.52	40
41	41.00	0.18	41.00	0.36	41.00	0.54	41
42	42.00	0.18	42.00	0.37	42.00	0.55	42
43	43.00	0.19	43.00	0.38	43.00	0.56	43
44	44.00	0.19	44.00	0.38	44.00	0.58	44
45	45.00	0.20	45.00	0.39	45.00	0.59	45
46	46.00	0.20	46.00	0.40	46.00	0.60	46
47	47.00	0.21	47.00	0.41	47.00	0.62	47
48	48.00	0.21	48.00	0.42	48.00	0.63	48
49	49.00	0.21	49.00	0.43	49.00	0.64	49
50	50.00	0.22	50.00	0.44	50.00	0.65	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89¾ Deg.		89½ Deg.		89¼ Deg.		

Distance.	¼ Deg.		½ Deg.		¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	51.00	0.22	51.00	0.45	51.00	0.67	51
52	52.00	0.23	52.00	0.45	52.00	0.68	52
53	53.00	0.23	53.00	0.46	53.00	0.69	53
54	54.00	0.24	54.00	0.47	54.00	0.71	54
55	55.00	0.24	55.00	0.48	55.00	0.72	55
56	56.00	0.24	56.00	0.49	56.00	0.73	56
57	57.00	0.25	57.00	0.50	57.00	0.75	57
58	58.00	0.25	58.00	0.51	57.99	0.76	58
59	59.00	0.26	59.00	0.51	58.99	0.77	59
60	60.00	0.26	60.00	0.52	59.99	0.79	60
61	61.00	0.27	61.00	0.53	60.99	0.80	61
62	62.00	0.27	62.00	0.54	61.99	0.81	62
63	63.00	0.27	63.00	0.55	62.99	0.82	63
64	64.00	0.28	64.00	0.56	63.99	0.84	64
65	65.00	0.28	65.00	0.57	64.99	0.85	65
66	66.00	0.29	66.00	0.58	65.99	0.86	66
67	67.00	0.29	67.00	0.58	66.99	0.88	67
68	68.00	0.30	68.00	0.59	67.99	0.89	68
69	69.00	0.30	69.00	0.60	68.99	0.90	69
70	70.00	0.31	70.00	0.61	69.99	0.92	70
71	71.00	0.31	71.00	0.62	70.99	0.93	71
72	72.00	0.31	72.00	0.63	71.99	0.94	72
73	73.00	0.32	73.00	0.64	72.99	0.96	73
74	74.00	0.32	74.00	0.65	73.99	0.97	74
75	75.00	0.33	75.00	0.65	74.99	0.98	75
76	76.00	0.33	76.00	0.66	75.99	0.99	76
77	77.00	0.34	77.00	0.67	76.99	1.01	77
78	78.00	0.34	78.00	0.68	77.99	1.02	78
79	79.00	0.34	79.00	0.69	78.99	1.03	79
80	80.00	0.35	80.00	0.70	79.99	1.05	80
81	81.00	0.35	81.00	0.71	80.99	1.06	81
82	82.00	0.36	82.00	0.72	81.99	1.07	82
83	83.00	0.36	83.00	0.72	82.99	1.09	83
84	84.00	0.37	84.00	0.73	83.99	1.10	84
85	85.00	0.37	85.00	0.74	84.99	1.11	85
86	86.00	0.38	86.00	0.75	85.99	1.13	86
87	87.00	0.38	87.00	0.76	86.99	1.14	87
88	88.00	0.38	88.00	0.77	87.99	1.15	88
89	89.00	0.39	89.00	0.78	88.99	1.16	89
90	90.00	0.39	90.00	0.79	89.99	1.18	90
91	91.00	0.40	91.00	0.79	90.99	1.19	91
92	92.00	0.40	92.00	0.80	91.99	1.20	92
93	93.00	0.41	93.00	0.81	92.99	1.22	93
94	94.00	0.41	94.00	0.82	93.99	1.23	94
95	95.00	0.41	95.00	0.83	94.99	1.24	95
96	96.00	0.42	96.00	0.84	95.99	1.26	96
97	97.00	0.42	97.00	0.85	96.99	1.27	97
98	98.00	0.43	98.00	0.86	97.99	1.28	98
99	99.00	0.43	99.00	0.86	98.99	1.30	99
100	100.00	0.44	100.00	0.87	99.99	1.31	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89¾ Deg.		89½ Deg.		89¼ Deg.		

Distance.	1 Deg.		1¼ Deg.		1½ Deg.		1¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.02	1.00	0.02	1.00	0.03	1.00	0.03	1
2	2.00	0.03	2.00	0.04	2.00	0.05	2.00	0.06	2
3	3.00	0.05	3.00	0.07	3.00	0.08	3.00	0.09	3
4	4.00	0.07	4.00	0.09	4.00	0.10	4.00	0.12	4
5	5.00	0.09	5.00	0.11	5.00	0.13	5.00	0.15	5
6	6.00	0.10	6.00	0.13	6.00	0.16	6.00	0.18	6
7	7.00	0.12	7.00	0.15	7.00	0.18	7.00	0.21	7
8	8.00	0.14	8.00	0.17	8.00	0.21	8.00	0.25	8
9	9.00	0.16	9.00	0.20	9.00	0.24	9.00	0.28	9
10	10.00	0.17	10.00	0.22	10.00	0.26	10.00	0.31	10
11	11.00	0.19	11.00	0.24	11.00	0.28	10.99	0.34	11
12	12.00	0.21	12.00	0.26	12.00	0.31	11.99	0.37	12
13	13.00	0.23	13.00	0.28	13.00	0.34	12.99	0.40	13
14	14.00	0.24	14.00	0.31	14.00	0.37	13.99	0.43	14
15	15.00	0.26	15.00	0.33	14.99	0.39	14.99	0.46	15
16	16.00	0.28	16.00	0.35	15.99	0.42	15.99	0.49	16
17	17.00	0.30	17.00	0.37	16.99	0.45	16.99	0.52	17
18	18.00	0.31	18.00	0.39	17.99	0.47	17.99	0.55	18
19	19.00	0.33	19.00	0.41	18.99	0.50	18.99	0.58	19
20	20.00	0.35	20.00	0.44	19.99	0.52	19.99	0.61	20
21	21.00	0.37	21.00	0.46	20.99	0.55	20.99	0.64	21
22	22.00	0.38	21.99	0.48	21.99	0.58	21.99	0.67	22
23	23.00	0.40	22.99	0.50	22.99	0.60	22.99	0.70	23
24	24.00	0.42	23.99	0.52	23.99	0.63	23.99	0.73	24
25	25.00	0.44	24.99	0.55	24.99	0.65	24.99	0.76	25
26	26.00	0.45	25.99	0.57	25.99	0.68	25.99	0.79	26
27	27.00	0.47	26.99	0.59	26.99	0.71	26.99	0.83	27
28	28.00	0.49	27.99	0.61	27.99	0.73	27.99	0.86	28
29	29.00	0.51	28.99	0.63	28.99	0.76	28.99	0.89	29
30	30.00	0.52	29.99	0.65	29.99	0.79	29.99	0.92	30
31	31.00	0.54	30.99	0.68	30.99	0.81	30.99	0.95	31
32	32.00	0.56	31.99	0.70	31.99	0.84	31.99	0.98	32
33	32.99	0.58	32.99	0.72	32.99	0.86	32.98	1.01	33
34	33.99	0.59	33.99	0.74	33.99	0.89	33.98	1.04	34
35	34.99	0.61	34.99	0.76	34.99	0.92	34.98	1.07	35
36	35.99	0.63	35.99	0.79	35.99	0.94	35.98	1.10	36
37	36.99	0.65	36.99	0.81	36.99	0.97	36.98	1.13	37
38	37.99	0.66	37.99	0.83	37.99	0.99	37.98	1.16	38
39	38.99	0.68	38.99	0.85	38.99	1.02	38.98	1.19	39
40	39.99	0.70	39.99	0.87	39.99	1.05	39.98	1.22	40
41	40.99	0.72	40.99	0.89	40.99	1.07	40.98	1.25	41
42	41.99	0.73	41.99	0.92	41.99	1.10	41.98	1.28	42
43	42.99	0.75	42.99	0.94	42.99	1.13	42.98	1.31	43
44	43.99	0.77	43.99	0.96	43.99	1.15	43.98	1.34	44
45	44.99	0.79	44.99	0.98	44.99	1.18	44.98	1.37	45
46	45.99	0.80	45.99	1.00	45.99	1.20	45.98	1.40	46
47	46.99	0.82	46.99	1.03	46.99	1.23	46.98	1.44	47
48	47.99	0.84	47.99	1.05	47.98	1.26	47.98	1.47	48
49	48.99	0.86	48.99	1.07	48.98	1.28	48.98	1.50	49
50	49.99	0.87	49.99	1.09	49.98	1.31	49.98	1.53	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89 Deg.		88¾ Deg.		88½ Deg.		88¼ Deg.		

Distance.	1 Deg.		1¼ Deg.		1½ Deg.		1¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.99	0.89	50.99	1.11	50.98	1.34	50.98	1.56	51
52	51.99	0.91	51.99	1.13	51.98	1.36	51.98	1.59	52
53	52.99	0.92	52.99	1.16	52.98	1.39	52.98	1.62	53
54	53.99	0.94	53.99	1.18	53.98	1.41	53.97	1.65	54
55	54.99	0.96	54.99	1.20	54.98	1.44	54.97	1.68	55
56	55.99	0.98	55.99	1.22	55.98	1.47	55.97	1.71	56
57	56.99	0.99	56.99	1.24	56.98	1.49	56.97	1.74	57
58	57.99	1.01	57.99	1.27	57.98	1.52	57.97	1.77	58
59	58.99	1.03	58.99	1.29	58.98	1.54	58.97	1.80	59
60	59.99	1.05	59.99	1.31	59.98	1.57	59.97	1.83	60
61	60.99	1.06	60.99	1.33	60.98	1.60	60.97	1.86	61
62	61.99	1.08	61.99	1.35	61.98	1.62	61.97	1.89	62
63	62.99	1.10	62.99	1.37	62.98	1.65	62.97	1.92	63
64	63.99	1.12	63.98	1.40	63.98	1.68	63.97	1.95	64
65	64.99	1.13	64.98	1.42	64.98	1.70	64.97	1.99	65
66	65.99	1.15	65.98	1.44	65.98	1.73	65.97	2.02	66
67	66.99	1.17	66.98	1.46	66.98	1.75	66.97	2.05	67
68	67.99	1.19	67.98	1.48	67.98	1.78	67.97	2.08	68
69	68.99	1.20	68.98	1.51	68.98	1.81	68.97	2.11	69
70	69.99	1.22	69.98	1.53	69.98	1.83	69.97	2.14	70
71	70.99	1.24	70.98	1.55	70.98	1.86	70.97	2.17	71
72	71.99	1.26	71.98	1.57	71.98	1.88	71.97	2.20	72
73	72.99	1.27	72.98	1.59	72.97	1.91	72.97	2.23	73
74	73.99	1.29	73.98	1.61	73.97	1.94	73.97	2.26	74
75	74.99	1.31	74.98	1.64	74.97	1.96	74.97	2.29	75
76	75.99	1.33	75.98	1.66	75.97	1.99	75.96	2.32	76
77	76.99	1.34	76.98	1.68	76.97	2.02	76.96	2.35	77
78	77.99	1.36	77.98	1.70	77.97	2.04	77.96	2.38	78
79	78.99	1.38	78.98	1.72	78.97	2.07	78.96	2.41	79
80	79.99	1.40	79.98	1.75	79.97	2.09	79.96	2.44	80
81	80.99	1.41	80.98	1.77	80.97	2.12	80.96	2.47	81
82	81.99	1.43	81.98	1.79	81.97	2.15	81.96	2.50	82
83	82.99	1.45	82.98	1.81	82.97	2.17	82.96	2.53	83
84	83.99	1.47	83.98	1.83	83.97	2.20	83.96	2.57	84
85	84.99	1.48	84.98	1.85	84.97	2.23	84.96	2.60	85
86	85.99	1.50	85.98	1.88	85.97	2.25	85.96	2.63	86
87	86.99	1.52	86.98	1.90	86.97	2.28	86.96	2.66	87
88	87.99	1.54	87.98	1.92	87.97	2.30	87.96	2.69	88
89	88.99	1.55	88.98	1.94	88.97	2.33	88.96	2.72	89
90	89.99	1.57	89.98	1.96	89.97	2.36	89.96	2.75	90
91	90.99	1.59	90.98	1.99	90.97	2.38	90.96	2.78	91
92	91.99	1.61	91.98	2.01	91.97	2.41	91.96	2.81	92
93	92.99	1.62	92.98	2.03	92.97	2.43	92.96	2.84	93
94	93.99	1.64	93.98	2.05	93.97	2.46	93.96	2.87	94
95	94.99	1.66	94.98	2.07	94.97	2.49	94.96	2.90	95
96	95.99	1.68	95.98	2.09	95.97	2.51	95.96	2.94	96
97	96.99	1.69	96.98	2.12	96.97	2.54	96.95	2.96	97
98	97.99	1.71	97.98	2.14	97.97	2.57	97.95	2.99	98
99	98.98	1.73	98.98	2.16	98.97	2.59	98.95	3.02	99
100	99.98	1.75	99.98	2.18	99.97	2.62	99.95	3.05	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89 Deg.		88¾ Deg.		88½ Deg.		88¼ Deg.		

Distance.	2 Deg.		2¼ Deg.		2½ Deg.		2¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.03	1.00	0.04	1.00	0.04	1.00	0.05	1
2	2.00	0.07	2.00	0.08	2.00	0.09	2.00	0.10	2
3	3.00	0.10	3.00	0.12	3.00	0.13	3.00	0.14	3
4	4.00	0.14	4.00	0.16	4.00	0.17	4.00	0.19	4
5	5.00	0.17	5.00	0.20	5.00	0.22	4.99	0.24	5
6	6.00	0.21	6.00	0.24	5.99	0.26	5.99	0.29	6
7	7.00	0.24	6.99	0.27	6.99	0.31	6.99	0.34	7
8	7.99	0.28	7.99	0.31	7.99	0.35	7.99	0.38	8
9	8.99	0.31	8.99	0.35	8.99	0.39	8.99	0.43	9
10	9.99	0.35	9.99	0.39	9.99	0.44	9.99	0.48	10
11	10.99	0.38	10.99	0.43	10.99	0.48	10.99	0.53	11
12	11.99	0.42	11.99	0.47	11.99	0.52	11.99	0.58	12
13	12.99	0.45	12.99	0.51	12.99	0.57	12.99	0.62	13
14	13.99	0.49	13.99	0.55	13.99	0.61	13.98	0.67	14
15	14.99	0.52	14.99	0.59	14.99	0.65	14.98	0.72	15
16	15.99	0.56	15.99	0.63	15.99	0.70	15.98	0.77	16
17	16.99	0.59	16.99	0.67	16.98	0.74	16.98	0.82	17
18	17.99	0.63	17.99	0.71	17.98	0.79	17.98	0.86	18
19	18.99	0.66	18.99	0.75	18.98	0.83	18.98	0.91	19
20	19.99	0.70	19.98	0.79	19.98	0.87	19.98	0.96	20
21	20.99	0.73	20.98	0.82	20.98	0.92	20.98	1.01	21
22	21.99	0.77	21.98	0.86	21.98	0.96	21.97	1.06	22
23	22.99	0.80	22.98	0.90	22.98	1.00	22.97	1.10	23
24	23.99	0.84	23.98	0.94	23.98	1.05	23.97	1.15	24
25	24.98	0.87	24.98	0.98	24.98	1.09	24.97	1.20	25
26	25.98	0.91	25.98	1.02	25.98	1.13	25.97	1.25	26
27	26.98	0.94	26.98	1.06	26.97	1.18	26.97	1.30	27
28	27.98	0.98	27.98	1.10	27.97	1.22	27.97	1.34	28
29	28.98	1.01	28.98	1.14	28.97	1.26	28.97	1.39	29
30	29.98	1.05	29.98	1.18	29.97	1.31	29.97	1.44	30
31	30.98	1.08	30.98	1.22	30.97	1.35	30.96	1.49	31
32	31.98	1.12	31.98	1.26	31.97	1.40	31.96	1.54	32
33	32.98	1.15	32.97	1.30	32.97	1.44	32.96	1.58	33
34	33.98	1.19	33.97	1.33	33.97	1.48	33.96	1.63	34
35	34.98	1.22	34.97	1.37	34.97	1.53	34.96	1.68	35
36	35.98	1.26	35.97	1.41	35.97	1.57	35.96	1.73	36
37	36.98	1.29	36.97	1.45	36.96	1.61	36.96	1.78	37
38	37.98	1.33	37.97	1.49	37.96	1.66	37.96	1.82	38
39	38.98	1.36	38.97	1.53	38.96	1.70	38.96	1.87	39
40	39.98	1.40	39.97	1.57	39.96	1.75	39.95	1.92	40
41	40.98	1.43	40.97	1.61	40.96	1.77	40.95	1.97	41
42	41.97	1.47	41.97	1.65	41.96	1.83	41.95	2.02	42
43	42.97	1.50	42.97	1.69	42.96	1.88	42.95	2.06	43
44	43.97	1.54	43.97	1.73	43.96	1.92	43.95	2.11	44
45	44.97	1.57	44.97	1.77	44.96	1.96	44.95	2.16	45
46	45.97	1.61	45.96	1.81	45.96	2.01	45.95	2.21	46
47	46.97	1.64	46.96	1.85	46.96	2.05	46.95	2.25	47
48	47.97	1.68	47.96	1.88	47.95	2.09	47.95	2.30	48
49	48.97	1.71	48.96	1.92	48.95	2.14	48.94	2.35	49
50	49.97	1.74	49.96	1.96	49.95	2.18	49.94	2.40	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	88 Deg.		87¾ Deg.		87½ Deg.		87¼ Deg.		

Distance.	2 Deg. Lat.	2 Deg. Dep.	2¼ Deg. Lat.	2¼ Deg. Dep.	2½ Deg. Lat.	2½ Deg. Dep.	2¼ Deg. Lat.	2¼ Deg. Dep.	Distance.
51	50.97	1.78	50.96	2.00	50.95	2.22	50.94	2.45	51
52	51.97	1.81	51.96	2.04	51.95	2.27	51.94	2.50	52
53	52.97	1.85	52.96	2.08	52.95	2.31	52.94	2.54	53
54	53.97	1.88	53.96	2.12	53.95	2.36	53.94	2.59	54
55	54.97	1.92	54.96	2.16	54.95	2.40	54.94	2.64	55
56	55.97	1.95	55.96	2.20	55.95	2.44	55.94	2.69	56
57	56.97	1.99	56.96	2.24	56.95	2.49	56.93	2.73	57
58	57.96	2.02	57.96	2.28	57.94	2.53	57.93	2.78	58
59	58.96	2.06	58.95	2.32	58.94	2.57	58.93	2.83	59
60	59.96	2.09	59.95	2.36	59.94	2.62	59.93	2.88	60
61	60.96	2.13	60.95	2.39	60.94	2.66	60.93	2.93	61
62	61.96	2.16	61.95	2.43	61.94	2.70	61.93	2.97	62
63	62.96	2.20	62.95	2.47	62.94	2.75	62.93	3.02	63
64	63.96	2.23	63.95	2.51	63.94	2.79	63.93	3.07	64
65	64.96	2.27	64.95	2.55	64.94	2.84	64.93	3.12	65
66	65.96	2.30	65.95	2.59	65.94	2.88	65.92	3.17	66
67	66.96	2.34	66.95	2.63	66.94	2.92	66.92	3.21	67
68	67.96	2.37	67.95	2.67	67.94	2.97	67.92	3.26	68
69	68.96	2.41	68.95	2.71	68.93	3.01	68.92	3.31	69
70	69.96	2.44	69.95	2.75	69.93	3.05	69.92	3.36	70
71	70.96	2.48	70.95	2.79	70.93	3.10	70.92	3.41	71
72	71.96	2.51	71.94	2.83	71.93	3.14	71.92	3.45	72
73	72.96	2.55	72.94	2.87	72.93	3.18	72.92	3.50	73
74	73.95	2.58	73.94	2.91	73.93	3.23	73.91	3.55	74
75	74.95	2.62	74.94	2.94	74.93	3.27	74.91	3.60	75
76	75.95	2.65	75.94	2.98	75.93	3.31	75.91	3.65	76
77	76.95	2.69	76.94	3.02	76.93	3.36	76.91	3.70	77
78	77.95	2.72	77.94	3.06	77.93	3.40	77.91	3.74	78
79	78.95	2.76	78.94	3.10	78.92	3.45	78.91	3.79	79
80	79.95	2.79	79.94	3.14	79.92	3.49	79.91	3.84	80
81	80.95	2.83	80.94	3.18	80.92	3.53	80.91	3.89	81
82	81.95	2.86	81.94	3.22	81.92	3.58	81.91	3.93	82
83	82.95	2.90	82.94	3.26	82.92	3.62	82.90	3.98	83
84	83.95	2.93	83.94	3.30	83.92	3.66	83.90	4.03	84
85	84.95	2.97	84.93	3.34	84.92	3.71	84.90	4.08	85
86	85.95	3.00	85.93	3.38	85.92	3.75	85.90	4.13	86
87	86.95	3.04	86.93	3.42	86.92	3.79	86.90	4.17	87
88	87.95	3.07	87.93	3.45	87.92	3.84	87.90	4.22	88
89	88.95	3.11	88.93	3.49	88.92	3.88	88.90	4.27	89
90	89.95	3.14	89.93	3.53	89.91	3.93	89.90	4.32	90
91	90.95	3.18	90.93	3.57	90.91	3.97	90.90	4.37	91
92	91.94	3.21	91.93	3.61	91.91	4.01	91.89	4.41	92
93	92.94	3.25	92.93	3.65	92.91	4.06	92.89	4.46	93
94	93.94	3.28	93.93	3.69	93.91	4.10	93.89	4.51	91
95	94.94	3.32	94.93	3.73	94.91	4.14	94.89	4.56	95
96	95.94	3.35	95.93	3.77	95.91	4.19	95.89	4.61	96
97	96.94	3.39	96.93	3.81	96.91	4.23	96.89	4.65	97
98	97.94	3.42	97.92	3.85	97.91	4.27	97.89	4.70	98
99	98.94	3.46	98.92	3.89	98.91	4.32	98.89	4.75	99
100	99.94	3.49	99.92	3.93	99.91	4.36	99.88	4.80	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	88 Deg.		87¾ Deg.		87½ Deg.		87¼ Deg.		

Distance.	3 Deg. Lat.	3 Deg. Dep.	3¼ Deg. Lat.	3¼ Deg. Dep.	3½ Deg. Lat.	3½ Deg. Dep.	3¾ Deg. Lat.	3¾ Deg. Dep.	Distance.
1	1.00	0.05	1.00	0.06	1.00	0.06	1.00	0.06	1
2	2.00	0.10	2.00	0.11	2.00	0.12	2.00	0.13	2
3	3.00	0.16	3.00	0.17	2.99	0.18	2.99	0.20	3
4	3.99	0.21	3.99	0.23	3.99	0.24	3.99	0.26	4
5	4.99	0.26	4.99	0.28	4.99	0.31	4.99	0.33	5
6	5.99	0.31	5.99	0.34	5.99	0.37	5.99	0.39	6
7	6.99	0.37	6.99	0.40	6.99	0.43	6.99	0.46	7
8	7.99	0.42	7.99	0.45	7.99	0.49	7.98	0.52	8
9	8.99	0.47	8.99	0.51	8.98	0.55	8.98	0.59	9
10	9.99	0.52	9.98	0.57	9.98	0.61	9.98	0.65	10
11	10.98	0.58	10.98	0.62	10.98	0.67	10.98	0.72	11
12	11.98	0.63	11.98	0.68	11.98	0.73	11.97	0.78	12
13	12.98	0.68	12.98	0.73	12.98	0.79	12.97	0.85	13
14	13.98	0.73	13.98	0.79	13.97	0.85	13.97	0.92	14
15	14.98	0.79	14.98	0.85	14.97	0.92	14.97	0.98	15
16	15.98	0.84	15.97	0.91	15.97	0.98	15.97	1.05	16
17	16.98	0.89	16.97	0.96	16.97	1.04	16.96	1.11	17
18	17.98	0.94	17.97	1.02	17.97	1.10	17.96	1.18	18
19	18.98	0.99	18.97	1.08	18.96	1.16	18.96	1.24	19
20	19.97	1.05	19.97	1.13	19.96	1.22	19.96	1.31	20
21	20.97	1.10	20.97	1.19	20.96	1.28	20.96	1.37	21
22	21.97	1.15	21.96	1.25	21.96	1.34	21.95	1.44	22
23	22.97	1.20	22.96	1.30	22.96	1.40	22.95	1.50	23
24	23.97	1.26	23.96	1.36	23.96	1.47	23.95	1.57	24
25	24.97	1.31	24.96	1.42	24.95	1.53	24.95	1.64	25
26	25.96	1.36	25.96	1.47	25.95	1.59	25.94	1.70	26
27	26.96	1.41	26.96	1.53	26.95	1.65	26.94	1.77	27
28	27.96	1.47	27.95	1.59	27.95	1.71	27.94	1.83	28
29	28.96	1.52	28.95	1.64	28.95	1.77	28.94	1.90	29
30	29.96	1.57	29.95	1.70	29.94	1.83	29.94	1.96	30
31	30.96	1.62	30.95	1.76	30.94	1.89	30.93	2.03	31
32	31.96	1.67	31.95	1.81	31.94	1.95	31.93	2.09	32
33	32.95	1.73	32.95	1.87	32.94	2.01	32.93	2.16	33
34	33.95	1.78	33.95	1.93	33.94	2.08	33.93	2.22	34
35	34.95	1.83	34.94	1.98	34.93	2.14	34.92	2.29	35
36	35.95	1.88	35.94	2.04	35.93	2.20	35.92	2.35	36
37	36.95	1.94	36.94	2.10	36.93	2.26	36.92	2.42	37
38	37.95	1.99	37.94	2.15	37.93	2.32	37.92	2.49	38
39	38.95	2.04	38.94	2.21	38.93	2.38	38.92	2.55	39
40	39.95	2.09	39.94	2.27	39.93	2.44	39.91	2.62	40
41	40.94	2.15	40.93	2.32	40.92	2.50	40.91	2.68	41
42	41.94	2.20	41.93	2.38	41.92	2.56	41.91	2.75	42
43	42.94	2.25	42.93	2.44	42.92	2.63	42.91	2.81	43
44	43.94	2.30	43.93	2.49	43.92	2.69	43.91	2.88	44
45	44.94	2.36	44.93	2.55	44.92	2.75	44.90	2.94	45
46	45.94	2.41	45.93	2.61	45.91	2.81	45.90	3.01	46
47	46.94	2.46	46.92	2.66	46.91	2.87	46.90	3.07	47
48	47.93	2.51	47.92	2.72	47.91	2.93	47.90	3.14	48
49	48.93	2.56	48.92	2.78	48.91	2.99	48.90	3.20	49
50	49.93	2.62	49.92	2.83	49.91	3.05	49.89	3.27	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	87 Deg.		86¾ Deg.		86½ Deg.		86¼ Deg.		

Distance.	3 Deg.		3¼ Deg.		3½ Deg.		3¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.93	2.67	50.92	2.89	50.90	3.11	50.89	3.34	51
52	51.93	2.72	51.92	2.95	51.90	3.17	51.89	3.40	52
53	52.93	2.77	52.91	3.00	52.90	3.24	52.89	3.47	53
54	53.93	2.83	53.91	3.06	53.90	3.30	53.88	3.53	54
55	54.92	2.88	54.91	3.12	54.90	3.36	54.88	3.60	55
56	55.92	2.93	55.91	3.17	55.90	3.42	55.88	3.66	56
57	56.92	2.98	56.91	3.23	56.89	3.48	56.88	3.73	57
58	57.92	3.04	57.91	3.29	57.89	3.54	57.88	3.79	58
59	58.92	3.09	58.91	3.34	58.89	3.60	58.87	3.86	59
60	59.92	3.14	59.90	3.40	59.89	3.66	59.87	3.92	60
61	60.92	3.19	60.90	3.46	60.89	3.72	60.87	3.99	61
62	61.92	3.24	61.90	3.51	61.88	3.79	61.87	4.05	62
63	62.91	3.30	62.90	3.57	62.88	3.85	62.87	4.12	63
64	63.91	3.35	63.90	3.63	63.88	3.91	63.86	4.19	64
65	64.91	3.40	64.90	3.69	64.88	3.97	64.86	4.25	65
66	65.91	3.45	65.89	3.74	65.88	4.03	65.86	4.32	66
67	66.91	3.51	66.89	3.80	66.88	4.09	66.86	4.38	67
68	67.91	3.56	67.89	3.85	67.87	4.15	67.85	4.45	68
69	68.91	3.61	68.89	3.91	68.87	4.21	68.85	4.51	69
70	69.90	3.66	69.89	3.97	69.87	4.27	69.85	4.58	70
71	70.90	3.72	70.89	4.03	70.87	4.33	70.85	4.64	71
72	71.90	3.77	71.88	4.08	71.87	4.40	71.85	4.71	72
73	72.90	3.82	72.88	4.14	72.86	4.46	72.84	4.77	73
74	73.90	3.87	73.88	4.20	73.86	4.52	73.84	4.84	74
75	74.90	3.93	74.88	4.25	74.86	4.58	74.84	4.91	75
76	75.90	3.98	75.88	4.31	75.86	4.64	75.84	4.97	76
77	76.89	4.03	76.88	4.37	76.86	4.70	76.84	5.04	77
78	77.89	4.08	77.87	4.42	77.85	4.76	77.83	5.10	78
79	78.89	4.13	78.87	4.48	78.85	4.82	78.83	5.17	79
80	79.89	4.19	79.87	4.54	79.85	4.88	79.83	5.23	80
81	80.89	4.24	80.87	4.59	80.85	4.94	80.83	5.30	81
82	81.89	4.29	81.87	4.65	81.85	5.01	81.82	5.36	82
83	82.89	4.34	82.87	4.71	82.85	5.07	82.82	5.43	83
84	83.88	4.40	83.86	4.76	83.84	5.13	83.82	5.49	84
85	84.88	4.45	84.86	4.82	84.84	5.19	84.82	5.56	85
86	85.88	4.50	85.86	4.88	85.84	5.25	85.82	5.62	86
87	86.88	4.55	86.86	4.93	86.84	5.31	86.81	5.69	87
88	87.88	4.61	87.86	4.99	87.84	5.37	87.81	5.76	88
89	88.88	4.66	88.86	5.05	88.83	5.43	88.81	5.82	89
90	89.88	4.71	89.86	5.10	89.83	5.49	89.81	5.89	90
91	90.88	4.76	90.85	5.16	90.83	5.56	90.81	5.95	91
92	91.87	4.81	91.85	5.22	91.83	5.62	91.80	6.02	92
93	92.87	4.87	92.85	5.27	92.83	5.68	92.80	6.08	93
94	93.87	4.92	93.85	5.33	93.82	5.74	93.80	6.15	94
95	94.87	4.97	94.85	5.39	94.82	5.80	94.80	6.21	95
96	95.87	5.02	95.85	5.44	95.82	5.86	95.79	6.28	96
97	96.87	5.08	96.84	5.50	96.82	5.92	96.79	6.34	97
98	97.87	5.13	97.84	5.56	97.82	5.98	97.79	6.41	98
99	98.86	5.18	98.84	5.61	98.82	6.04	98.79	6.47	99
100	99.86	5.23	99.84	5.67	99.81	6.10	99.79	6.54	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	87 Deg.		86¾ Deg.		86½ Deg.		86¼ Deg.		

Distance.	4 Deg.		4¼ Deg.		4½ Deg.		4¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.07	1.00	0.07	1.00	0.08	1.00	0.08	1
2	2.00	0.14	1.99	0.15	1.99	0.16	1.99	0.17	2
3	2.99	0.21	2.99	0.22	2.99	0.24	2.99	0.25	3
4	3.99	0.28	3.99	0.30	3.99	0.31	3.98	0.33	4
5	4.99	0.35	4.99	0.37	4.98	0.39	4.98	0.41	5
6	5.99	0.42	5.98	0.44	5.98	0.47	5.98	0.50	6
7	6.98	0.49	6.98	0.52	6.98	0.55	6.97	0.58	7
8	7.98	0.56	7.98	0.59	7.98	0.63	7.97	0.66	8
9	8.98	0.63	8.98	0.67	8.97	0.71	8.97	0.75	9
10	9.98	0.70	9.97	0.74	9.97	0.78	9.97	0.83	10
11	10.97	0.77	10.97	0.82	10.97	0.86	10.96	0.91	11
12	11.97	0.84	11.97	0.89	11.96	0.94	11.96	0.99	12
13	12.97	0.91	12.96	0.96	12.96	1.02	12.96	1.08	13
14	13.97	0.98	13.96	1.04	13.96	1.10	13.95	1.16	14
15	14.96	1.05	14.96	1.11	14.95	1.18	14.95	1.24	15
16	15.96	1.12	15.96	1.19	15.95	1.26	15.95	1.32	16
17	16.96	1.19	16.95	1.26	16.95	1.33	16.94	1.41	17
18	17.96	1.26	17.95	1.33	17.94	1.41	17.94	1.49	18
19	18.95	1.33	18.95	1.40	18.94	1.49	18.93	1.57	19
20	19.95	1.40	19.95	1.48	19.94	1.57	19.93	1.66	20
21	20.95	1.46	20.94	1.56	20.94	1.65	20.93	1.74	21
22	21.95	1.53	21.94	1.63	21.93	1.73	21.92	1.82	22
23	22.94	1.60	22.94	1.70	22.93	1.80	22.92	1.90	23
24	23.94	1.67	23.93	1.78	23.93	1.88	23.92	1.99	24
25	24.94	1.74	24.93	1.85	24.92	1.96	24.91	2.07	25
26	25.94	1.81	25.93	1.93	25.92	2.04	25.91	2.15	26
27	26.93	1.88	26.93	2.00	26.92	2.12	26.91	2.24	27
28	27.93	1.95	27.92	2.08	27.91	2.20	27.90	2.32	28
29	28.93	2.02	28.92	2.15	28.91	2.28	28.90	2.40	29
30	29.93	2.09	29.92	2.22	29.91	2.35	29.90	2.48	30
31	30.92	2.16	30.91	2.30	30.90	2.43	30.89	2.57	31
32	31.92	2.23	31.91	2.37	31.90	2.51	31.89	2.65	32
33	32.92	2.30	32.91	2.45	32.90	2.59	32.89	2.73	33
34	33.92	2.37	33.91	2.52	33.90	2.67	33.88	2.82	34
35	34.91	2.44	34.90	2.59	34.89	2.75	34.88	2.90	35
36	35.91	2.51	35.90	2.67	35.89	2.82	35.88	2.98	36
37	36.91	2.58	36.90	2.74	36.89	2.90	36.87	3.06	37
38	37.91	2.65	37.90	2.82	37.88	2.98	37.87	3.15	38
39	38.90	2.72	38.89	2.89	38.88	3.06	38.87	3.23	39
40	39.90	2.79	39.89	2.96	39.88	3.14	39.86	3.31	40
41	40.90	2.86	40.89	3.04	40.87	3.22	40.86	3.40	41
42	41.90	2.93	41.88	3.11	41.87	3.30	41.86	3.48	42
43	42.90	3.00	42.88	3.19	42.87	3.37	42.85	3.56	43
44	43.89	3.07	43.88	3.26	43.86	3.45	43.85	3.64	44
45	44.89	3.14	44.88	3.33	44.86	3.53	44.85	3.73	45
46	45.89	3.21	45.87	3.41	45.86	3.61	45.84	3.81	46
47	46.89	3.28	46.87	3.48	46.86	3.69	46.84	3.89	47
48	47.88	3.35	47.87	3.56	47.85	3.77	47.84	3.97	48
49	48.88	3.42	48.87	3.63	48.85	3.84	48.83	4.06	49
50	49.88	3.49	49.86	3.71	49.85	3.92	49.83	4.14	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	86 Deg.		85¾ Deg.		85½ Deg.		85¼ Deg.		

Distance.	4 Deg.		4¼ Deg.		4½ Deg.		4¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.88	3.56	50.86	3.78	50.84	4.00	50.82	4.22	51
52	51.87	3.63	51.86	3.85	51.84	4.08	51.82	4.31	52
53	52.87	3.70	52.85	3.93	52.84	4.16	52.82	4.39	53
54	53.87	3.77	53.85	4.00	53.83	4.24	53.81	4.47	54
55	54.87	3.84	54.85	4.08	54.83	4.32	54.81	4.55	55
56	55.86	3.91	55.85	4.15	55.83	4.39	55.81	4.64	56
57	56.86	3.98	56.84	4.22	56.82	4.47	56.80	4.72	57
58	57.86	4.05	57.84	4.30	57.82	4.55	57.80	4.80	58
59	58.86	4.12	58.84	4.37	58.82	4.63	58.80	4.89	59
60	59.85	4.19	59.84	4.45	59.82	4.71	59.79	4.97	60
61	60.85	4.26	60.83	4.52	60.81	4.79	60.79	5.05	61
62	61.85	4.32	61.83	4.59	61.81	4.86	61.79	5.13	62
63	62.85	4.39	62.83	4.67	62.81	4.94	62.78	5.22	63
64	63.84	4.46	63.82	4.74	63.80	5.02	63.78	5.30	64
65	64.84	4.53	64.82	4.82	64.80	5.10	64.78	5.38	65
66	65.84	4.60	65.82	4.89	65.80	5.18	65.77	5.47	66
67	66.84	4.67	66.82	4.97	66.79	5.26	66.77	5.55	67
68	67.83	4.74	67.81	5.04	67.79	5.34	67.77	5.63	68
69	68.83	4.81	68.81	5.11	68.79	5.41	68.76	5.71	69
70	69.83	4.88	69.81	5.19	69.78	5.49	69.76	5.80	70
71	70.83	4.95	70.80	5.26	70.78	5.57	70.76	5.88	71
72	71.82	5.02	71.80	5.34	71.78	5.65	71.75	5.96	72
73	72.82	5.09	72.80	5.41	72.77	5.73	72.75	6.04	73
74	73.82	5.16	73.80	5.48	73.77	5.81	73.75	6.13	74
75	74.82	5.23	74.79	5.56	74.77	5.88	74.74	6.21	75
76	75.81	5.30	75.79	5.63	75.77	5.96	75.74	6.29	76
77	76.81	5.37	76.79	5.71	76.76	6.04	76.74	6.38	77
78	77.81	5.44	77.79	5.78	77.76	6.12	77.73	6.46	78
79	78.81	5.51	78.78	5.85	78.76	6.20	78.73	6.54	79
80	79.81	5.58	79.78	5.93	79.75	6.28	79.73	6.62	80
81	80.80	5.65	80.78	6.00	80.75	6.36	80.72	6.71	81
82	81.80	5.72	81.78	6.08	81.75	6.43	81.72	6.79	82
83	82.80	5.79	82.77	6.15	82.74	6.51	82.71	6.87	83
84	83.80	5.86	83.77	6.23	83.74	6.59	83.71	6.96	84
85	84.79	5.93	84.77	6.30	84.74	6.67	84.71	7.04	85
86	85.79	6.00	85.76	6.37	85.73	6.75	85.70	7.12	86
87	86.79	6.07	86.76	6.45	86.73	6.83	86.70	7.20	87
88	87.79	6.14	87.76	6.52	87.73	6.90	87.70	7.29	88
89	88.78	6.21	88.76	6.60	88.73	6.98	88.70	7.37	89
90	89.78	6.28	89.75	6.67	89.72	7.06	89.69	7.45	90
91	90.78	6.35	90.75	6.74	90.72	7.14	90.69	7.54	91
92	91.78	6.42	91.75	6.82	91.72	7.22	91.68	7.62	92
93	92.77	6.49	92.74	6.89	92.71	7.30	92.68	7.70	93
94	93.77	6.56	93.74	6.97	93.71	7.38	93.68	7.78	94
95	94.77	6.63	94.74	7.04	94.71	7.45	94.67	7.87	95
96	95.77	6.70	95.74	7.11	95.70	7.53	95.67	7.95	96
97	96.76	6.77	96.73	7.19	96.70	7.61	96.67	8.03	97
98	97.76	6.84	97.73	7.26	97.70	7.69	97.66	8.12	98
99	98.76	6.91	98.73	7.34	98.69	7.77	98.66	8.20	99
100	99.76	6.98	99.73	7.41	99.69	7.85	99.66	8.28	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	86 Deg.		85¾ Deg.		85½ Deg.		85¼ Deg.		

Distance.	5 Deg.		5¼ Deg.		5½ Deg.		5¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.09	1.00	0.09	1.00	0.10	0.99	0.10	1
2	1.99	0.17	1.99	0.18	1.99	0.19	1.99	0.20	2
3	2.99	0.26	2.99	0.27	2.99	0.29	2.98	0.30	3
4	3.98	0.35	3.98	0.37	3.98	0.38	3.98	0.40	4
5	4.98	0.44	4.98	0.46	4.98	0.48	4.97	0.50	5
6	5.98	0.52	5.97	0.55	5.97	0.58	5.97	0.60	6
7	6.97	0.61	6.97	0.64	6.97	0.67	6.96	0.70	7
8	7.97	0.70	7.97	0.73	7.96	0.76	7.96	0.80	8
9	8.97	0.78	8.96	0.82	8.96	0.86	8.95	0.90	9
10	9.96	0.87	9.96	0.92	9.95	0.96	9.95	1.00	10
11	10.96	0.96	10.95	1.01	10.95	1.05	10.94	1.10	11
12	11.95	1.05	11.95	1.10	11.94	1.15	11.94	1.20	12
13	12.95	1.13	12.95	1.19	12.94	1.25	12.93	1.30	13
14	13.95	1.22	13.94	1.28	13.94	1.34	13.93	1.40	14
15	14.94	1.31	14.94	1.37	14.93	1.44	14.92	1.50	15
16	15.94	1.39	15.93	1.46	15.93	1.53	15.92	1.60	16
17	16.94	1.48	16.93	1.56	16.92	1.63	16.91	1.70	17
18	17.93	1.57	17.92	1.65	17.92	1.73	17.91	1.80	18
19	18.93	1.66	18.92	1.74	18.91	1.82	18.90	1.90	19
20	19.92	1.74	19.92	1.83	19.91	1.92	19.90	2.00	20
21	20.92	1.83	20.91	1.92	20.90	2.01	20.89	2.10	21
22	21.92	1.92	21.91	2.01	21.90	2.11	21.89	2.20	22
23	22.91	2.00	22.90	2.10	22.89	2.20	22.88	2.30	23
24	23.91	2.09	23.90	2.20	23.89	2.30	23.88	2.40	24
25	24.90	2.18	24.90	2.29	24.88	2.40	24.87	2.50	25
26	25.90	2.27	25.89	2.38	25.88	2.49	25.87	2.60	26
27	26.90	2.35	26.89	2.47	26.88	2.59	26.86	2.71	27
28	27.89	2.44	27.88	2.56	27.87	2.68	27.86	2.81	28
29	28.89	2.53	28.88	2.65	28.87	2.78	28.85	2.91	29
30	29.89	2.61	29.87	2.75	29.86	2.88	29.85	3.01	30
31	30.88	2.70	30.87	2.84	30.86	2.97	30.84	3.11	31
32	31.88	2.79	31.87	2.93	31.85	3.07	31.84	3.21	32
33	32.87	2.88	32.86	3.02	32.85	3.16	32.83	3.31	33
34	33.87	2.96	33.86	3.11	33.84	3.26	33.83	3.41	34
35	34.87	3.05	34.85	3.20	34.84	3.35	34.82	3.51	35
36	35.86	3.14	35.85	3.29	35.83	3.45	35.82	3.61	36
37	36.86	3.22	36.84	3.39	36.83	3.55	36.81	3.71	37
38	37.86	3.31	37.84	3.48	37.83	3.64	37.81	3.81	38
39	38.85	3.40	38.84	3.57	38.82	3.74	38.80	3.91	39
40	39.85	3.49	39.83	3.66	39.82	3.83	39.80	4.01	40
41	40.84	3.57	40.83	3.75	40.81	3.93	40.79	4.11	41
42	41.84	3.66	41.82	3.84	41.81	4.03	41.79	4.21	42
43	42.84	3.75	42.82	3.93	42.80	4.12	42.78	4.31	43
44	43.83	3.83	43.82	4.03	43.80	4.22	43.78	4.41	44
45	44.83	3.92	44.81	4.12	44.79	4.31	44.77	4.51	45
46	45.82	4.01	45.81	4.21	45.79	4.41	45.77	4.61	46
47	46.82	4.10	46.80	4.30	46.78	4.50	46.76	4.71	47
48	47.82	4.18	47.80	4.39	47.78	4.60	47.76	4.81	48
49	48.81	4.27	48.79	4.48	48.77	4.70	48.75	4.91	49
50	49.81	4.36	49.79	4.58	49.77	4.79	49.75	5.01	50
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance.	85 Deg.		84¾ Deg.		84½ Deg.		84¼ Deg.		Distance.

Distance	5 Deg. Lat.	5 Deg. Dep.	5¼ Deg. Lat.	5¼ Deg. Dep.	5½ Deg. Lat.	5½ Deg. Dep.	5¾ Deg. Lat.	5¾ Deg. Dep.	Distance
51	50.81	4.44	50.79	4.67	50.77	4.89	50.74	5.11	51
52	51.80	4.53	51.78	4.76	51.76	4.98	51.74	5.21	52
53	52.80	4.62	52.78	4.85	52.76	5.08	52.73	5.31	53
54	53.79	4.71	53.77	4.94	53.75	5.18	53.73	5.41	54
55	54.79	4.79	54.77	5.03	54.75	5.27	54.72	5.51	55
56	55.79	4.88	55.77	5.12	55.74	5.37	55.72	5.61	56
57	56.78	4.97	56.76	5.22	56.74	5.46	56.71	5.71	57
58	57.78	5.06	57.76	5.31	57.73	5.56	57.71	5.81	58
59	58.78	5.14	58.75	5.40	58.73	5.65	58.70	5.91	59
60	59.77	5.23	59.75	5.49	59.72	5.75	59.70	6.01	60
61	60.77	5.32	60.74	5.58	60.72	5.85	60.69	6.11	61
62	61.76	5.40	61.74	5.67	61.71	5.94	61.69	6.21	62
63	62.76	5.49	62.74	5.76	62.71	6.04	62.68	6.31	63
64	63.76	5.58	63.73	5.86	63.71	6.13	63.68	6.41	64
65	64.75	5.67	64.73	5.95	64.70	6.23	64.67	6.51	65
66	65.75	5.75	65.72	6.04	65.70	6.33	65.67	6.61	66
67	66.75	5.84	66.72	6.13	66.69	6.42	66.66	6.71	67
68	67.74	5.93	67.71	6.22	67.69	6.52	67.66	6.81	68
69	68.74	6.01	68.71	6.31	68.68	6.61	68.65	6.91	69
70	69.73	6.10	69.71	6.41	69.68	6.71	69.65	7.01	70
71	70.73	6.19	70.70	6.50	70.67	6.81	70.64	7.11	71
72	71.73	6.28	71.70	6.59	71.67	6.90	71.64	7.21	72
73	72.72	6.36	72.69	6.68	72.66	7.00	72.63	7.31	73
74	73.72	6.45	73.69	6.77	73.66	7.09	73.63	7.41	74
75	74.71	6.54	74.69	6.86	74.65	7.19	74.62	7.51	75
76	75.71	6.62	75.68	6.95	75.65	7.28	75.62	7.61	76
77	76.71	6.71	76.68	7.05	76.65	7.38	76.61	7.71	77
78	77.70	6.80	77.67	7.14	77.64	7.48	77.61	7.81	78
79	78.70	6.89	78.67	7.23	78.64	7.57	78.60	7.91	79
80	79.70	6.97	79.66	7.32	79.63	7.67	79.60	8.02	80
81	80.69	7.06	80.66	7.41	80.63	7.76	80.59	8.12	81
82	81.69	7.15	81.66	7.50	81.62	7.86	81.59	8.22	82
83	82.68	7.23	82.65	7.59	82.62	7.96	82.58	8.32	83
84	83.68	7.32	83.65	7.69	83.61	8.05	83.58	8.42	84
85	84.68	7.41	84.64	7.78	84.61	8.15	84.57	8.52	85
86	85.67	7.50	85.64	7.87	85.60	8.24	85.57	8.62	86
87	86.67	7.58	86.64	7.96	86.60	8.34	86.56	8.72	87
88	87.67	7.67	87.63	8.05	87.59	8.43	87.56	8.82	88
89	88.66	7.76	88.63	8.14	88.59	8.53	88.55	8.92	89
90	89.66	7.84	89.62	8.24	89.59	8.63	89.55	9.02	90
91	90.65	7.93	90.62	8.33	90.58	8.72	90.54	9.12	91
92	91.65	8.02	91.61	8.42	91.58	8.82	91.54	9.22	92
93	92.65	8.11	92.61	8.51	92.57	8.91	92.53	9.32	93
94	93.64	8.19	93.61	8.60	93.57	9.01	93.53	9.42	94
95	94.64	8.28	94.60	8.69	94.56	9.11	94.52	9.52	95
96	95.63	8.37	95.60	8.78	95.56	9.20	95.52	9.62	96
97	96.63	8.45	96.59	8.88	96.55	9.30	96.51	9.72	97
98	97.63	8.54	97.59	8.97	97.55	9.39	97.51	9.82	98
99	98.62	8.63	98.59	9.06	98.54	9.49	98.50	9.92	99
100	99.62	8.72	99.58	9.15	99.54	9.58	99.50	10.02	100
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	85 Deg.		84¾ Deg.		84½ Deg.		84¼ Deg.		

Distance.	6 Deg.		6¼ Deg.		6½ Deg.		6¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.99	0.10	0.99	0.11	0.99	0.11	0.99	0.12	1
2	1.99	0.21	1.99	0.22	1.99	0.23	1.99	0.24	2
3	2.98	0.31	2.98	0.33	2.98	0.34	2.98	0.35	3
4	3.98	0.41	3.98	0.44	3.97	0.45	3.97	0.47	4
5	4.97	0.52	4.97	0.54	4.97	0.57	4.97	0.59	5
6	5.97	0.63	5.96	0.65	5.96	0.68	5.96	0.71	6
7	6.96	0.73	6.96	0.76	6.96	0.79	6.95	0.82	7
8	7.96	0.84	7.95	0.87	7.95	0.91	7.94	0.94	8
9	8.95	0.94	8.95	0.98	8.94	1.02	8.94	1.06	9
10	9.95	1.05	9.94	1.09	9.94	1.13	9.93	1.18	10
11	10.94	1.15	10.93	1.20	10.93	1.25	10.92	1.29	11
12	11.93	1.25	11.93	1.31	11.92	1.36	11.92	1.41	12
13	12.93	1.36	12.92	1.42	12.92	1.47	12.91	1.53	13
14	13.92	1.46	13.92	1.52	13.91	1.59	13.90	1.65	14
15	14.92	1.57	14.91	1.63	14.90	1.70	14.90	1.76	15
16	15.91	1.67	15.90	1.74	15.90	1.81	15.89	1.88	16
17	16.91	1.78	16.90	1.85	16.89	1.92	16.88	2.00	17
18	17.90	1.88	17.89	1.96	17.88	2.04	17.88	2.12	18
19	18.90	1.99	18.89	2.07	18.88	2.15	18.87	2.23	19
20	19.89	2.09	19.88	2.18	19.87	2.26	19.86	2.35	20
21	20.88	2.20	20.88	2.29	20.87	2.38	20.85	2.47	21
22	21.88	2.30	21.87	2.40	21.86	2.49	21.85	2.59	22
23	22.87	2.40	22.86	2.50	22.85	2.60	22.84	2.70	23
24	23.87	2.51	23.86	2.61	23.85	2.72	23.83	2.82	24
25	24.86	2.61	24.85	2.72	24.84	2.83	24.83	2.94	25
26	25.86	2.72	25.85	2.83	25.83	2.94	25.82	3.06	26
27	26.85	2.82	26.84	2.94	26.83	3.06	26.81	3.17	27
28	27.85	2.93	27.83	3.05	27.82	3.17	27.81	3.29	28
29	28.84	3.03	28.83	3.16	28.81	3.28	28.80	3.41	29
30	29.84	3.14	29.82	3.27	29.81	3.40	29.79	3.53	30
31	30.83	3.24	30.82	3.37	30.80	3.51	30.79	3.64	31
32	31.82	3.34	31.81	3.48	31.79	3.62	31.78	3.76	32
33	32.82	3.45	32.80	3.59	32.79	3.74	32.77	3.88	33
34	33.81	3.55	33.80	3.70	33.78	3.85	33.76	4.00	34
35	34.81	3.66	34.79	3.81	34.78	3.96	34.76	4.11	35
36	35.80	3.76	35.79	3.92	35.77	4.08	35.75	4.23	36
37	36.80	3.87	36.78	4.03	36.76	4.19	36.75	4.35	37
38	37.79	3.97	37.77	4.14	37.76	4.30	37.74	4.47	38
39	38.79	4.08	38.77	4.25	38.75	4.41	38.73	4.58	39
40	39.78	4.18	39.76	4.35	39.74	4.53	39.72	4.70	40
41	40.78	4.29	40.76	4.46	40.74	4.64	40.72	4.82	41
42	41.77	4.39	41.75	4.57	41.73	4.76	41.71	4.94	42
43	42.76	4.49	42.74	4.68	42.72	4.87	42.70	5.05	43
44	43.76	4.60	43.74	4.79	43.72	4.98	43.70	5.17	44
45	44.75	4.70	44.73	4.90	44.71	5.09	44.69	5.29	45
46	45.75	4.81	45.73	5.01	45.70	5.21	45.68	5.41	46
47	46.74	4.91	46.72	5.12	46.70	5.32	46.67	5.52	47
48	47.74	5.02	47.71	5.23	47.69	5.43	47.67	5.64	48
49	48.73	5.12	48.71	5.34	48.69	5.55	48.66	5.76	49
50	49.73	5.23	49.70	5.44	49.68	5.66	49.65	5.88	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	84 Deg.		83¾ Deg.		83½ Deg.		83¼ Deg.		

Distance.	6 Deg.		6¼ Deg.		6½ Deg		6¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.72	5.33	50.70	5.55	50.67	5.77	50.65	5.99	51
52	51.72	5.44	51.69	5.66	51.67	5.89	51.64	6.11	52
53	52.71	5.54	52.68	5.77	52.66	6.00	52.63	6.23	53
54	53.70	5.64	53.68	5.88	53.65	6.11	53.63	6.35	54
55	54.70	5.75	54.67	5.99	54.65	6.23	54.62	6.46	55
56	55.69	5.85	55.67	6.10	55.64	6.34	55.61	6.58	56
57	56.69	5.96	56.66	6.21	56.63	6.45	56.60	6.70	57
58	57.68	6.06	57.66	6.31	57.63	6.57	57.60	6.82	58
59	58.68	6.17	58.65	6.42	58.62	6.68	58.59	6.93	59
60	59.67	6.27	59.64	6.53	59.61	6.79	59.58	7.05	60
61	60.67	6.38	60.64	6.64	60.61	6.91	60.58	7.17	61
62	61.66	6.48	61.63	6.75	61.60	7.02	61.57	7.29	62
63	62.65	6.59	62.63	6.86	62.60	7.13	62.56	7.40	63
64	63.65	6.69	63.62	6.97	63.59	7.25	63.56	7.52	64
65	64.64	6.79	64.61	7.08	64.58	7.36	64.55	7.64	65
66	65.64	6.90	65.61	7.19	65.58	7.47	65.54	7.76	66
67	66.63	7.00	66.60	7.29	66.57	7.58	66.54	7.88	67
68	67.63	7.11	67.60	7.40	67.56	7.70	67.53	7.99	68
69	68.62	7.21	68.59	7.51	68.56	7.81	68.52	8.11	69
70	69.62	7.32	69.58	7.62	69.55	7.92	69.51	8.23	70
71	70.61	7.42	70.58	7.73	70.54	8.04	70.51	8.35	71
72	71.61	7.53	71.57	7.84	71.54	8.15	71.50	8.46	72
73	72.60	7.63	72.57	7.95	72.53	8.26	72.49	8.58	73
74	73.59	7.74	73.56	8.06	73.52	8.38	73.49	8.70	74
75	74.59	7.84	74.55	8.17	74.52	8.49	74.48	8.82	75
76	75.58	7.94	75.55	8.27	75.51	8.60	75.47	8.93	76
77	76.58	8.05	76.54	8.38	76.51	8.72	76.47	9.05	77
78	77.57	8.15	77.54	8.49	77.50	8.83	77.46	9.17	78
79	78.57	8.26	78.53	8.60	78.49	8.94	78.45	9.29	79
80	79.56	8.36	79.53	8.71	79.49	9.06	79.45	9.40	80
81	80.56	8.47	80.52	8.82	80.48	9.17	80.44	9.52	81
82	81.55	8.57	81.51	8.93	81.47	9.28	81.43	9.64	82
83	82.55	8.68	82.51	9.04	82.47	9.40	82.42	9.76	83
84	83.54	8.78	83.50	9.14	83.46	9.51	83.42	9.87	84
85	84.53	8.88	84.50	9.25	84.45	9.62	84.41	9.99	85
86	85.53	8.99	85.49	9.36	85.45	9.74	85.40	10.11	86
87	86.52	9.09	86.48	9.47	86.44	9.85	86.40	10.23	87
88	87.52	9.20	87.48	9.58	87.43	9.96	87.39	10.34	88
89	88.51	9.30	88.47	9.69	88.43	10.08	88.38	10.46	89
90	89.51	9.41	89.47	9.80	89.42	10.19	89.38	10.58	90
91	90.50	9.51	90.46	9.91	90.42	10.30	90.37	10.70	91
92	91.50	9.62	91.45	10.02	91.41	10.41	91.36	10.81	92
93	92.49	9.72	92.45	10.12	92.40	10.53	92.36	10.93	93
94	93.49	9.83	93.44	10.23	93.40	10.64	93.35	11.05	94
95	94.48	9.93	94.44	10.34	94.39	10.75	94.34	11.17	95
96	95.47	10.03	95.43	10.45	95.38	10.87	95.33	11.28	96
97	96.47	10.14	96.42	10.56	96.38	10.98	96.33	11.40	97
98	97.46	10.24	97.42	10.67	97.37	11.09	97.32	11.52	98
99	98.46	10.35	98.41	10.78	98.36	11.21	98.31	11.64	99
100	99.45	10.45	99.41	10.89	99.36	11.32	99.31	11.75	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	84 Deg.		83¾ Deg.		83½ Deg.		83¼ Deg.		

Distance	7 Deg.		7¼ Deg.		7½ Deg.		7¾ Deg.		Distance
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.99	0.12	0.99	0.13	0.99	0.13	0.99	0.13	1
2	1.99	0.24	1.98	0.25	1.98	0.26	1.98	0.27	2
3	2.98	0.37	2.98	0.38	2.97	0.39	2.97	0.40	3
4	3.97	0.49	3.97	0.50	3.97	0.52	3.96	0.54	4
5	4.96	0.61	4.96	0.63	4.96	0.65	4.95	0.67	5
6	5.96	0.73	5.95	0.76	5.95	0.78	5.95	0.81	6
7	6.95	0.85	6.94	0.88	6.94	0.91	6.94	0.94	7
8	7.94	0.97	7.94	1.01	7.93	1.04	7.93	1.08	8
9	8.93	1.10	8.93	1.14	8.92	1.17	8.92	1.21	9
10	9.93	1.22	9.92	1.26	9.91	1.31	9.91	1.35	10
11	10.92	1.34	10.91	1.39	10.91	1.44	10.90	1.48	11
12	11.91	1.46	11.90	1.51	11.90	1.57	11.89	1.62	12
13	12.90	1.58	12.90	1.64	12.89	1.70	12.88	1.75	13
14	13.90	1.71	13.89	1.77	13.88	1.83	13.87	1.89	14
15	14.89	1.83	14.88	1.89	14.87	1.96	14.86	2.02	15
16	15.88	1.95	15.87	2.02	15.86	2.09	15.85	2.16	16
17	16.87	2.07	16.86	2.15	16.85	2.22	16.84	2.29	17
18	17.87	2.19	17.86	2.27	17.85	2.35	17.84	2.43	18
19	18.86	2.32	18.85	2.40	18.84	2.48	18.83	2.56	19
20	19.85	2.44	19.84	2.52	19.83	2.61	19.82	2.70	20
21	20.84	2.56	20.83	2.65	20.82	2.74	20.81	2.83	21
22	21.84	2.68	21.82	2.78	21.81	2.87	21.80	2.97	22
23	22.83	2.80	22.82	2.90	22.80	3.00	22.79	3.10	23
24	23.82	2.92	23.81	3.03	23.79	3.13	23.78	3.24	24
25	24.81	3.05	24.80	3.15	24.79	3.26	24.77	3.37	25
26	25.81	3.17	25.79	3.28	25.78	3.39	25.76	3.51	26
27	26.80	3.29	26.78	3.41	26.77	3.52	26.75	3.64	27
28	27.79	3.41	27.78	3.53	27.76	3.65	27.74	3.78	28
29	28.78	3.53	28.77	3.66	28.75	3.79	28.74	3.91	29
30	29.78	3.66	29.76	3.79	29.74	3.92	29.73	4.05	30
31	30.77	3.78	30.75	3.91	30.73	4.05	30.72	4.18	31
32	31.76	3.90	31.74	4.04	31.73	4.18	31.71	4.32	32
33	32.75	4.02	32.74	4.16	32.72	4.31	32.70	4.45	33
34	33.75	4.14	33.73	4.29	33.71	4.44	33.69	4.58	34
35	34.74	4.27	34.72	4.42	34.70	4.57	34.68	4.72	35
36	35.73	4.39	35.71	4.54	35.69	4.70	35.67	4.85	36
37	36.72	4.51	36.70	4.67	36.68	4.83	36.66	4.99	37
38	37.72	4.63	37.70	4.80	37.67	4.96	37.65	5.12	38
39	38.71	4.75	38.69	4.92	38.67	5.09	38.64	5.26	39
40	39.70	4.87	39.68	5.05	39.66	5.22	39.63	5.39	40
41	40.70	5.00	40.67	5.17	40.65	5.35	40.63	5.53	41
42	41.69	5.12	41.66	5.30	41.64	5.48	41.62	5.66	42
43	42.68	5.24	42.66	5.43	42.63	5.61	42.61	5.80	43
44	43.67	5.36	43.65	5.55	43.62	5.74	43.60	5.93	44
45	44.67	5.48	44.64	5.68	44.62	5.87	44.59	6.07	45
46	45.66	5.61	45.63	5.81	45.61	6.00	45.58	6.20	46
47	46.65	5.73	46.62	5.93	46.60	6.13	46.57	6.34	47
48	47.64	5.85	47.62	6.06	47.59	6.27	47.56	6.47	48
49	48.63	5.97	48.61	6.18	48.58	6.40	48.55	6.61	49
50	49.63	6.09	49.60	6.31	49.57	6.53	49.54	6.74	50
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	83 Deg.		82¾ Deg.		82½ Deg.		82¼ Deg.		

Distance.	7 Deg.		7¼ Deg.		7½ Deg.		7¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.62	6.22	50.59	6.44	50.56	6.66	50.53	6.88	51
52	51.61	6.34	51.58	6.56	51.56	6.79	51.53	7.01	52
53	52.60	6.46	52.58	6.69	52.55	6.92	52.52	7.15	53
54	53.60	6.58	53.57	6.81	53.54	7.05	53.51	7.28	54
55	54.59	6.70	54.56	6.94	54.53	7.18	54.50	7.42	55
56	55.58	6.82	55.55	7.07	55.52	7.31	55.49	7.55	56
57	56.58	6.95	56.54	7.19	56.51	7.44	56.48	7.69	57
58	57.57	7.07	57.54	7.32	57.50	7.57	57.47	7.82	58
59	58.56	7.19	58.53	7.45	58.50	7.70	58.46	7.96	59
60	59.55	7.31	59.52	7.57	59.49	7.83	59.45	8.09	60
61	60.55	7.43	60.51	7.70	60.48	7.96	60.44	8.23	61
62	61.54	7.56	61.50	7.82	61.47	8.09	61.43	8.36	62
63	62.53	7.68	62.50	7.95	62.46	8.22	62.42	8.50	63
64	63.52	7.80	63.49	8.08	63.45	8.35	63.42	8.63	64
65	64.52	7.92	64.48	8.20	64.44	8.48	64.41	8.77	65
66	65.51	8.04	65.47	8.33	65.44	8.61	65.40	8.90	66
67	66.50	8.17	66.46	8.46	66.43	8.75	66.39	9.04	67
68	67.49	8.29	67.46	8.58	67.42	8.88	67.38	9.17	68
69	68.49	8.41	68.45	8.71	68.41	9.01	68.37	9.30	69
70	69.48	8.53	69.44	8.83	69.40	9.14	69.36	9.44	70
71	70.47	8.65	70.43	8.96	70.39	9.27	70.35	9.57	71
72	71.46	8.77	71.42	9.09	71.38	9.40	71.34	9.71	72
73	72.46	8.90	72.42	9.21	72.38	9.53	72.33	9.84	73
74	73.45	9.02	73.41	9.34	73.37	9.66	73.32	9.98	74
75	74.44	9.14	74.40	9.46	74.36	9.79	74.31	10.11	75
76	75.43	9.26	75.39	9.59	75.35	9.92	75.31	10.25	76
77	76.43	9.38	76.38	9.72	76.34	10.05	76.30	10.38	77
78	77.42	9.51	77.38	9.84	77.33	10.18	77.29	10.52	78
79	78.41	9.63	78.37	9.97	78.32	10.31	78.28	10.65	79
80	79.40	9.75	79.36	10.10	79.32	10.44	79.27	10.79	80
81	80.40	9.87	80.35	10.22	80.31	10.57	80.26	10.92	81
82	81.39	9.99	81.34	10.35	81.30	10.70	81.25	11.06	82
83	82.38	10.12	82.34	10.47	82.29	10.83	82.24	11.19	83
84	83.37	10.24	83.33	10.60	83.28	10.96	83.23	11.33	84
85	84.37	10.36	84.32	10.73	84.27	11.09	84.22	11.46	85
86	85.36	10.48	85.31	10.85	85.26	11.23	85.21	11.60	86
87	86.35	10.60	86.30	10.98	86.26	11.36	86.21	11.73	87
88	87.34	10.72	87.30	11.11	87.25	11.49	87.20	11.87	88
89	88.34	10.85	88.29	11.23	88.24	11.62	88.19	12.00	89
90	89.33	10.97	89.28	11.36	89.23	11.75	89.18	12.14	90
91	90.32	11.09	90.27	11.48	90.22	11.88	90.17	12.27	91
92	91.31	11.21	91.26	11.61	91.21	12.01	91.16	12.41	92
93	92.31	11.33	92.26	11.74	92.20	12.14	92.15	12.54	93
94	93.30	11.46	93.25	11.86	93.20	12.27	93.14	12.68	94
95	94.29	11.58	94.24	11.99	94.19	12.40	94.13	12.81	95
96	95.28	11.70	95.23	12.12	95.18	12.53	95.12	12.95	96
97	96.28	11.82	96.22	12.24	96.17	12.66	96.11	13.08	97
98	97.27	11.94	97.22	12.37	97.16	12.79	97.10	13.22	98
99	98.26	12.07	98.21	12.49	98.15	12.92	98.10	13.35	99
100	99.25	12.19	99.20	12.62	99.14	13.05	99.09	13.49	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	83 Deg.		82¾ Deg.		82½ Deg.		82¼ Deg.		

Distance.	8 Deg.		8¼ Deg.		8½ Deg.		8¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.99	0.14	0.99	0.14	0.99	0.15	0.99	0.15	1
2	1.98	0.28	1.98	0.29	1.98	0.30	1.98	0.30	2
3	2.97	0.42	2.97	0.43	2.97	0.44	2.97	0.46	3
4	3.96	0.56	3.96	0.57	3.96	0.59	3.95	0.61	4
5	4.95	0.70	4.95	0.72	4.95	0.74	4.94	0.76	5
6	5.94	0.84	5.94	0.86	5.93	0.89	5.93	0.91	6
7	6.93	0.97	6.93	1.00	6.92	1.03	6.92	1.06	7
8	7.92	1.11	7.92	1.15	7.91	1.18	7.91	1.22	8
9	8.91	1.25	8.91	1.29	8.90	1.33	8.90	1.37	9
10	9.90	1.39	9.90	1.43	9.89	1.48	9.88	1.52	10
11	10.89	1.53	10.89	1.58	10.88	1.63	10.87	1.67	11
12	11.88	1.67	11.88	1.72	11.87	1.77	11.86	1.83	12
13	12.87	1.81	12.87	1.87	12.86	1.92	12.85	1.98	13
14	13.86	1.95	13.86	2.01	13.85	2.07	13.84	2.13	14
15	14.85	2.09	14.85	2.15	14.84	2.22	14.83	2.28	15
16	15.84	2.23	15.84	2.30	15.82	2.36	15.81	2.43	16
17	16.83	2.37	16.83	2.44	16.81	2.51	16.80	2.59	17
18	17.82	2.51	17.81	2.58	17.80	2.66	17.79	2.74	18
19	18.82	2.64	18.80	2.73	18.79	2.81	18.78	2.89	19
20	19.81	2.78	19.79	2.87	19.78	2.96	19.77	3.04	20
21	20.80	2.92	20.78	3.01	20.77	3.10	20.76	3.19	21
22	21.79	3.06	21.77	3.16	21.76	3.25	21.74	3.35	22
23	22.78	3.20	22.76	3.30	22.75	3.40	22.73	3.50	23
24	23.77	3.34	23.75	3.44	23.74	3.55	23.72	3.65	24
25	24.76	3.48	24.74	3.59	24.73	3.70	24.71	3.80	25
26	25.75	3.62	25.73	3.73	25.71	3.84	25.70	3.96	26
27	26.74	3.76	26.72	3.87	26.70	3.99	26.69	4.11	27
28	27.73	3.90	27.71	4.02	27.69	4.14	27.67	4.26	28
29	28.72	4.04	28.70	4.16	28.68	4.29	28.66	4.41	29
30	29.71	4.18	29.69	4.30	29.67	4.43	29.65	4.56	30
31	30.70	4.31	30.68	4.45	30.66	4.58	30.64	4.72	31
32	31.69	4.45	31.67	4.59	31.65	4.73	31.63	4.87	32
33	32.68	4.59	32.66	4.74	32.64	4.88	32.62	5.02	33
34	33.67	4.73	33.65	4.88	33.63	5.03	33.60	5.17	34
35	34.66	4.87	34.64	5.02	34.62	5.17	34.59	5.32	35
36	35.65	5.01	35.63	5.17	35.60	5.32	35.58	5.48	36
37	36.64	5.15	36.62	5.31	36.59	5.47	36.57	5.63	37
38	37.63	5.29	37.61	5.45	37.58	5.62	37.56	5.78	38
39	38.62	5.43	38.60	5.60	38.57	5.76	38.55	5.93	39
40	39.61	5.57	39.59	5.74	39.56	5.91	39.53	6.08	40
41	40.60	5.71	40.58	5.88	40.55	6.06	40.52	6.24	41
42	41.59	5.85	41.57	6.03	41.54	6.21	41.51	6.39	42
43	42.58	5.98	42.56	6.17	42.53	6.36	42.50	6.54	43
44	43.57	6.12	43.54	6.31	43.52	6.50	43.49	6.69	44
45	44.56	6.26	44.53	6.46	44.51	6.65	44.48	6.85	45
46	45.55	6.40	45.52	6.60	45.49	6.80	45.46	7.00	46
47	46.54	6.54	46.51	6.74	46.48	6.95	46.45	7.15	47
48	47.53	6.68	47.50	6.89	47.47	7.09	47.44	7.30	48
49	48.52	6.82	48.49	7.03	48.46	7.24	48.43	7.45	49
50	49.51	6.96	49.48	7.17	49.45	7.39	49.42	7.61	50
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance.	82 Deg.		81¾ Deg.		81½ Deg.		81¼ Deg.		Distance.

Distance.	8 Deg.		8¼ Deg.		8½ Deg.		8¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.50	7.10	50.47	7.32	50.44	7.54	50.41	7.76	51
52	51.49	7.24	51.46	7.46	51.43	7.69	51.39	7.91	52
53	52.48	7.38	52.45	7.61	52.42	7.83	52.38	8.06	53
54	53.47	7.52	53.44	7.75	53.41	7.98	53.37	8.21	54
55	54.46	7.65	54.43	7.89	54.40	8.13	54.36	8.37	55
56	55.46	7.79	55.42	8.04	55.38	8.28	55.35	8.52	56
57	56.45	7.93	56.41	8.18	56.37	8.43	56.34	8.67	57
58	57.44	8.07	57.40	8.32	57.36	8.57	57.32	8.82	58
59	58.43	8.21	58.39	8.47	58.35	8.72	58.31	8.98	59
60	59.42	8.35	59.38	8.61	59.34	8.87	59.30	9.13	60
61	60.41	8.49	60.37	8.75	60.33	9.02	60.29	9.28	61
62	61.40	8.63	61.36	8.90	61.32	9.16	61.28	9.43	62
63	62.39	8.77	62.35	9.04	62.31	9.31	62.27	9.58	63
64	63.38	8.91	63.34	9.18	63.30	9.46	63.26	9.74	64
65	64.37	9.05	64.33	9.33	64.29	9.61	64.24	9.89	65
66	65.36	9.19	65.32	9.47	65.28	9.76	65.23	10.04	66
67	66.35	9.32	66.31	9.61	66.26	9.90	66.22	10.19	67
68	67.34	9.46	67.30	9.76	67.25	10.05	67.21	10.34	68
69	68.33	9.60	68.29	9.90	68.24	10.20	68.20	10.50	69
70	69.32	9.74	69.28	10.04	69.23	10.35	69.19	10.65	70
71	70.31	9.88	70.27	10.19	70.22	10.49	70.17	10.80	71
72	71.30	10.02	71.25	10.33	71.21	10.64	71.16	10.95	72
73	72.29	10.16	72.24	10.47	72.20	10.79	72.15	11.10	73
74	73.28	10.30	73.23	10.62	73.19	10.94	73.14	11.26	74
75	74.27	10.44	74.22	10.76	74.18	11.09	74.13	11.41	75
76	75.26	10.58	75.21	10.91	75.17	11.23	75.12	11.56	76
77	76.25	10.72	76.20	11.05	76.15	11.38	76.10	11.71	77
78	77.24	10.86	77.19	11.19	77.14	11.53	77.09	11.87	78
79	78.23	10.99	78.18	11.34	78.13	11.68	78.08	12.02	79
80	79.22	11.13	79.17	11.48	79.12	11.82	79.07	12.17	80
81	80.21	11.27	80.16	11.62	80.11	11.97	80.06	12.32	81
82	81.20	11.41	81.15	11.77	81.10	12.12	81.05	12.47	82
83	82.19	11.55	82.14	11.91	82.09	12.27	82.03	12.63	83
84	83.18	11.69	83.13	12.05	83.08	12.42	83.02	12.78	84
85	84.17	11.83	84.12	12.20	84.07	12.56	84.01	12.93	85
86	85.16	11.97	85.11	12.34	85.06	12.71	85.00	13.08	86
87	86.15	12.11	86.10	12.48	86.04	12.86	85.99	13.23	87
88	87.14	12.25	87.09	12.63	87.03	13.01	86.98	13.39	88
89	88.13	12.39	88.08	12.77	88.02	13.16	87.96	13.54	89
90	89.12	12.53	89.07	12.91	89.01	13.30	88.95	13.69	90
91	90.11	12.66	90.06	13.06	90.00	13.45	89.94	13.84	91
92	91.10	12.80	91.05	13.20	90.99	13.60	90.93	14.00	92
93	92.09	12.94	92.04	13.34	91.98	13.75	91.92	14.15	93
94	93.09	13.08	93.03	13.49	92.97	13.80	92.91	14.30	94
95	94.08	13.22	94.02	13.63	93.96	14.04	93.89	14.45	95
96	95.07	13.36	95.01	13.78	94.95	14.19	94.88	14.60	96
97	96.06	13.50	96.00	13.92	95.93	14.34	95.87	14.76	97
98	97.05	13.64	96.99	14.06	96.92	14.49	96.86	14.91	98
99	98.04	13.78	97.98	14.21	97.91	14.63	97.85	15.06	99
100	99.03	13.92	98.97	14.35	98.90	14.78	98.84	15.21	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	82 Deg.		81¾ Deg.		81½ Deg.		81¼ Deg.		

Distance.	9 Deg.		9¼ Deg.		9½ Deg.		9¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.99	0.16	0.99	0.16	0.99	0.17	0.99	0.17	1
2	1.98	0.31	1.97	0.32	1.97	0.33	1.97	0.34	2
3	2.96	0.47	2.96	0.48	2.96	0.50	2.96	0.51	3
4	3.95	0.63	3.95	0.64	3.95	0.66	3.94	0.68	4
5	4.94	0.78	4.93	0.80	4.93	0.83	4.93	0.85	5
6	5.93	0.94	5.92	0.96	5.92	0.99	5.91	1.02	6
7	6.91	1.10	6.91	1.13	6.90	1.16	6.90	1.19	7
8	7.90	1.25	7.90	1.29	7.89	1.32	7.88	1.35	8
9	8.89	1.41	8.88	1.45	8.88	1.49	8.87	1.52	9
10	9.88	1.56	9.87	1.61	9.86	1.65	9.86	1.69	10
11	10.86	1.72	10.86	1.77	10.85	1.82	10.84	1.86	11
12	11.85	1.88	11.84	1.93	11.84	1.98	11.83	2.03	12
13	12.84	2.03	12.83	2.09	12.82	2.15	12.81	2.20	13
14	13.83	2.19	13.82	2.25	13.81	2.31	13.80	2.37	14
15	14.82	2.35	14.80	2.41	14.79	2.48	14.78	2.54	15
16	15.80	2.50	15.79	2.57	15.78	2.64	15.77	2.71	16
17	16.79	2.66	16.78	2.73	16.77	2.81	16.75	2.88	17
18	17.78	2.82	17.77	2.89	17.75	2.97	17.74	3.05	18
19	18.77	2.97	18.75	3.05	18.74	3.14	18.73	3.22	19
20	19.75	3.13	19.74	3.21	19.73	3.30	19.71	3.39	20
21	20.74	3.29	20.73	3.38	20.71	3.47	20.70	3.56	21
22	21.73	3.44	21.71	3.54	21.70	3.63	21.68	3.73	22
23	22.72	3.60	22.70	3.70	22.68	3.80	22.67	3.90	23
24	23.70	3.75	23.69	3.86	23.87	3.96	23.65	4.06	24
25	24.69	3.91	24.67	4.02	24.66	4.13	24.64	4.23	25
26	25.68	4.07	25.66	4.18	25.64	4.29	25.62	4.40	26
27	26.67	4.22	26.65	4.34	26.63	4.45	26.61	4.57	27
28	27.66	4.38	27.64	4.50	27.62	4.62	27.60	4.74	28
29	28.64	4.54	28.62	4.66	28.60	4.79	28.58	4.91	29
30	29.63	4.69	29.61	4.82	29.59	4.95	29.57	5.09	30
31	30.62	4.85	30.59	4.98	30.57	5.12	30.55	5.25	31
32	31.61	5.01	31.58	5.14	31.56	5.28	31.54	5.42	32
33	32.59	5.16	32.57	5.30	32.55	5.45	32.52	5.59	33
34	33.58	5.32	33.56	5.47	33.53	5.61	33.51	5.76	34
35	34.57	5.48	34.54	5.63	34.52	5.78	34.49	5.93	35
36	35.56	5.63	35.53	5.79	35.51	5.94	35.48	6.10	36
37	36.54	5.79	36.52	5.95	36.49	6.11	36.47	6.27	37
38	37.53	5.94	37.51	6.11	37.48	6.27	37.45	6.44	38
39	38.52	6.10	38.49	6.27	38.47	6.44	38.44	6.60	39
40	39.51	6.26	39.48	6.43	39.45	6.60	39.42	6.77	40
41	40.50	6.41	40.47	6.59	40.44	6.77	40.41	6.94	41
42	41.48	6.57	41.45	6.75	41.42	6.92	41.39	7.11	42
43	42.47	6.73	42.44	6.91	42.41	7.10	42.38	7.28	43
44	43.46	6.88	43.43	7.07	43.40	7.26	43.36	7.45	44
45	44.45	7.04	44.41	7.23	44.38	7.43	44.35	7.62	45
46	45.43	7.20	45.40	7.39	45.37	7.59	45.34	7.79	46
47	46.42	7.35	46.39	7.55	46.36	7.76	46.32	7.96	47
48	47.41	7.51	47.38	7.72	47.34	7.92	47.31	8.13	48
49	48.40	7.67	48.36	7.88	48.33	8.09	48.29	8.30	49
50	49.38	7.82	49.35	8.04	49.32	8.25	49.28	8.47	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	81 Deg.		80¾ Deg.		80½ Deg.		80¼ Deg.		

Distance.	9 Deg. Lat.	9 Deg. Dep.	9¼ Deg Lat.	9¼ Deg Dep.	9½ Deg. Lat.	9½ Deg. Dep.	9¾ Deg. Lat.	9¾ Deg. Dep.	Distance.
51	50.37	7.98	50.34	8.20	50.30	8.42	50.26	8.64	51
52	51.36	8.13	51.32	8.36	51.29	8.58	51.25	8.81	52
53	52.35	8.29	52.31	8.52	52.27	8.75	52.23	8.98	53
54	53.34	8.45	53.30	8.68	53.26	8.91	53.22	9.14	54
55	54.32	8.60	54.28	8.84	54.25	9.08	54.21	9.31	55
56	55.31	8.76	55.27	9.00	55.23	9.24	55.19	9.48	56
57	56.30	8.92	56.26	9.16	56.22	9.41	56.18	9.65	57
58	57.29	9.07	57.25	9.32	57.20	9.57	57.16	9.82	58
59	58.27	9.23	58.23	9.48	58.19	9.74	58.15	9.99	59
60	59.26	9.39	59.22	9.64	59.18	9.90	59.13	10.16	60
61	60.25	9.54	60.21	9.81	60.16	10.07	60.12	10.33	61
62	61.24	9.70	61.19	9.97	61.15	10.23	61.10	10.50	62
63	62.22	9.86	62.18	10.13	62.14	10.40	62.09	10.67	63
64	63.21	10.01	63.17	10.29	63.12	10.56	63.08	10.84	64
65	64.20	10.17	64.16	10.45	64.11	10.73	64.06	11.01	65
66	65.19	10.32	65.14	10.61	65.09	10.89	65.05	11.18	66
67	66.18	10.48	66.13	10.77	66.08	11.06	66.03	11.35	67
68	67.16	10.64	67.12	10.93	67.07	11.22	67.02	11.52	68
69	68.15	10.79	68.10	11.09	68.05	11.39	68.00	11.69	69
70	69.14	10.95	69.09	11.25	69.04	11.55	68.99	11.85	70
71	70.13	11.11	70.08	11.41	70.03	11.72	69.97	12.02	71
72	71.11	11.26	71.06	11.57	71.01	11.88	70.96	12.19	72
73	72.10	11.42	72.05	11.73	72.00	12.05	71.95	12.36	73
74	73.09	11.58	73.04	11.89	72.99	12.21	72.93	12.53	74
75	74.08	11.73	74.02	12.06	73.97	12.38	73.92	12.70	75
76	75.06	11.89	75.01	12.22	74.96	12.54	74.90	12.87	76
77	76.05	12.05	76.00	12.38	75.94	12.71	75.89	13.04	77
78	77.04	12.20	76.99	12.54	76.93	12.87	76.87	13.21	78
79	78.03	12.36	77.97	12.70	77.92	13.04	77.86	13.38	79
80	79.02	12.51	78.96	12.86	78.90	13.20	78.84	13.55	80
81	80.00	12.67	79.95	13.02	79.89	13.37	79.83	13.72	81
82	80.99	12.83	80.93	13.18	80.88	13.53	80.82	13.89	82
83	81.98	12.98	81.92	13.34	81.86	13.70	81.80	14.06	83
84	82.97	13.14	82.91	13.50	82.85	13.86	82.79	14.23	84
85	83.95	13.30	83.89	13.66	83.83	14.03	83.77	14.39	85
86	84.94	13.45	84.88	13.82	84.82	14.19	84.76	14.56	86
87	85.93	13.61	85.87	13.98	85.81	14.36	85.74	14.73	87
88	86.92	13.77	86.86	14.15	86.79	14.52	86.73	14.90	88
89	87.90	13.92	87.84	14.31	87.78	14.69	87.71	15.07	89
90	88.89	14.08	88.83	14.47	88.77	14.85	88.70	15.24	90
91	89.88	14.24	89.82	14.63	89.75	15.02	89.69	15.41	91
92	90.87	14.39	90.80	14.79	90.74	15.18	90.67	15.58	92
93	91.86	14.55	91.79	14.95	91.72	15.35	91.66	15.75	93
94	92.84	14.70	92.78	15.11	92.71	15.51	92.64	15.92	94
95	93.83	14.86	93.76	15.27	93.70	15.68	93.63	16.09	95
96	94.82	15.02	94.75	15.43	94.68	15.84	94.61	16.26	96
97	95.81	15.17	95.74	15.59	95.67	16.01	95.60	16.43	97
98	96.79	15.33	96.73	15.75	96.66	16.17	96.58	16.60	98
99	97.78	15.49	97.71	15.91	97.64	16.34	97.57	16.77	99
100	98.77	15.64	98.70	16.07	98.63	16.50	98.56	16.93	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	81 Deg.		80¾ Deg.		80½ Deg.		80¼ Deg.		

Distance.	10 Deg.		10¼ Deg.		10½ Deg.		10¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	
1	0.98	0.17	0.98	0.18	0.98	0.18	0.98	0.19	1
2	1.97	0.35	1.97	0.36	1.97	0.36	1.96	0.37	2
3	2.95	0.52	2.95	0.53	2.95	0.55	2.95	0.56	3
4	3.94	0.69	3.94	0.71	3.93	0.73	3.93	0.75	4
5	4.92	0.87	4.92	0.89	4.92	0.91	4.91	0.93	5
6	5.91	1.04	5.90	1.07	5.90	1.09	5.89	1.12	6
7	6.89	1.22	6.89	1.25	6.88	1.28	6.88	1.31	7
8	7.88	1.39	7.87	1.42	7.87	1.46	7.86	1.49	8
9	8.86	1.56	8.86	1.60	8.85	1.64	8.84	1.68	9
10	9.85	1.74	9.84	1.78	9.83	1.82	9.82	1.87	10
11	10.83	1.91	10.82	1.96	10.82	2.00	10.81	2.05	11
12	11.82	2.08	11.81	2.14	11.80	2.19	11.79	2.24	12
13	12.80	2.26	12.79	2.31	12.78	2.37	12.77	2.42	13
14	13.79	2.43	13.78	2.49	13.77	2.55	13.75	2.61	14
15	14.77	2.60	14.76	2.67	14.75	2.73	14.74	2.80	15
16	15.76	2.78	15.74	2.85	15.73	2.92	15.72	2.98	16
17	16.74	2.95	16.73	3.03	16.72	3.10	16.70	3.17	17
18	17.73	3.13	17.71	3.20	17.70	3.28	17.68	3.36	18
19	18.71	3.30	18.70	3.38	18.68	3.46	18.67	3.54	19
20	19.70	3.47	19.68	3.56	19.67	3.64	19.65	3.73	20
21	20.68	3.65	20.66	3.74	20.65	3.83	20.63	3.92	21
22	21.67	3.82	21.65	3.91	21.63	4.01	21.61	4.10	22
23	22.65	3.99	22.63	4.03	22.61	4.19	22.60	4.29	23
24	23.64	4.17	23.62	4.27	23.60	4.37	23.58	4.48	24
25	24.62	4.34	24.60	4.45	24.58	4.56	24.56	4.66	25
26	25.61	4.51	25.59	4.63	25.56	4.74	25.54	4.85	26
27	26.59	4.69	26.57	4.80	26.55	4.92	26.53	5.04	27
28	27.57	4.86	27.55	4.98	27.53	5.10	27.51	5.22	28
29	28.56	5.04	28.54	5.16	28.51	5.28	28.49	5.41	29
30	29.54	5.21	29.52	5.34	29.50	5.47	29.47	5.60	30
31	30.53	5.38	30.51	5.52	30.48	5.65	30.46	5.78	31
32	31.51	5.56	31.49	5.69	31.46	5.83	31.44	5.97	32
33	32.50	5.73	32.47	5.87	32.45	6.01	32.42	6.16	33
34	33.48	5.90	33.46	6.05	33.43	6.20	33.40	6.34	34
35	34.47	6.08	34.44	6.23	34.41	6.38	34.39	6.53	35
36	35.45	6.25	35.43	6.41	35.40	6.56	35.37	6.71	36
37	36.44	6.42	36.41	6.58	36.38	6.74	36.35	6.90	37
38	37.42	6.60	37.39	6.76	37.36	6.92	37.33	7.09	38
39	38.41	6.77	38.38	6.94	38.35	7.11	38.32	7.27	39
40	39.39	6.95	39.36	7.12	39.33	7.29	39.30	7.46	40
41	40.38	7.12	40.35	7.30	40.31	7.47	40.28	7.65	41
42	41.36	7.29	41.33	7.47	41.30	7.65	41.26	7.83	42
43	42.35	7.47	42.31	7.65	42.28	7.84	42.25	8.02	43
44	43.33	7.64	43.30	7.83	43.26	8.02	43.23	8.21	44
45	44.32	7.81	44.28	8.01	44.25	8.20	44.21	8.39	45
46	45.30	7.99	45.27	8.19	45.23	8.38	45.19	8.58	46
47	46.29	8.16	46.25	8.36	46.21	8.57	46.18	8.77	47
48	47.27	8.34	47.23	8.54	47.20	8.75	47.16	8.95	48
49	48.26	8.51	48.22	8.72	48.18	8.93	48.14	9.14	49
50	49.24	8.68	49.20	8.90	49.16	9.11	49.12	9.33	50
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance.	80 Deg.		79¾ Deg.		79½ Deg.		79¼ Deg.		Distance.

Distance.	10 Deg.		10¼ Deg.		10½ Deg.		10¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.23	8.86	50.19	9.08	50.15	9.29	50.10	9.51	51
52	51.21	9.03	51.17	9.25	51.13	9.48	51.09	9.70	52
53	52.19	9.20	52.15	9.43	52.11	9.66	52.07	9.89	53
54	53.18	9.38	53.14	9.61	53.10	9.84	53.05	10.07	54
55	54.16	9.55	54.12	9.79	54.08	10.02	54.03	10.26	55
56	55.15	9.72	55.11	9.96	55.06	10.21	55.02	10.45	56
57	56.13	9.90	56.09	10.14	56.05	10.39	56.00	10.63	57
58	57.12	10.07	57.07	10.32	57.03	10.57	56.98	10.82	58
59	58.10	10.25	58.06	10.50	58.01	10.75	57.96	11.00	59
60	59.09	10.42	59.04	10.68	59.00	10.93	58.95	11.19	60
61	60.07	10.59	60.03	10.85	59.98	11.12	59.93	11.38	61
62	61.06	10.77	61.01	11.03	60.96	11.30	60.91	11.56	62
63	62.04	10.94	61.99	11.21	61.95	11.48	61.89	11.75	63
64	63.03	11.11	62.98	11.39	62.93	11.66	62.88	11.94	64
65	64.01	11.29	63.96	11.57	63.91	11.85	63.86	12.12	65
66	65.00	11.46	64.95	11.74	64.89	12.03	64.84	12.31	66
67	65.98	11.63	65.93	11.92	65.88	12.21	65.82	12.50	67
68	66.97	11.81	66.91	12.10	66.86	12.39	66.81	12.68	68
69	67.95	11.98	67.90	12.28	67.84	12.57	67.79	12.87	69
70	68.94	12.16	68.88	12.46	68.83	12.76	68.77	13.06	70
71	69.92	12.33	69.87	12.63	69.81	12.94	69.75	13.24	71
72	70.91	12.50	70.85	12.81	70.79	13.12	70.74	13.43	72
73	71.89	12.68	71.83	12.99	71.78	13.30	71.72	13.62	73
74	72.88	12.85	72.82	13.17	72.76	13.49	72.70	13.80	74
75	73.86	13.02	73.80	13.35	73.74	13.67	73.68	13.99	75
76	74.85	13.20	74.79	13.52	74.73	13.85	74.67	14.18	76
77	75.83	13.37	75.77	13.70	75.71	14.03	75.65	14.36	77
78	76.82	13.54	76.76	13.88	76.69	14.21	76.63	14.55	78
79	77.80	13.72	77.74	14.06	77.68	14.40	77.61	14.74	79
80	78.78	13.89	78.72	14.24	78.66	14.58	78.60	14.92	80
81	79.77	14.07	79.71	14.41	79.64	14.76	79.58	15.11	81
82	80.75	14.24	80.69	14.59	80.63	14.94	80.56	15.29	82
83	81.74	14.41	81.68	14.77	81.61	15.13	81.54	15.48	83
84	82.72	14.59	82.66	14.95	82.59	15.31	82.53	15.67	84
85	83.71	14.76	83.64	15.13	83.58	15.49	83.51	15.85	85
86	84.69	14.93	84.63	15.30	84.56	15.67	84.49	16.04	86
87	85.68	15.11	85.61	15.48	85.54	15.85	85.47	16.23	87
88	86.66	15.28	86.60	15.66	86.53	16.04	86.46	16.41	88
89	87.65	15.45	87.58	15.84	87.51	16.22	87.44	16.60	89
90	88.63	15.63	88.56	16.01	88.49	16.40	88.42	16.79	90
91	89.62	15.80	89.55	16.19	89.48	16.58	89.40	16.97	91
92	90.60	15.98	90.53	16.37	90.46	16.77	90.39	17.16	92
93	91.59	16.15	91.52	16.55	91.44	16.95	91.37	17.35	93
94	92.57	16.32	92.50	16.73	92.43	17.13	92.35	17.53	94
95	93.56	16.50	93.48	16.90	93.41	17.31	93.33	17.72	95
96	94.54	16.67	94.47	17.08	94.39	17.49	94.32	17.91	96
97	95.53	16.84	95.45	17.26	95.38	17.68	95.30	18.09	97
98	96.51	17.02	96.44	17.44	96.36	17.86	96.29	18.28	98
99	97.50	17.19	97.42	17.62	97.34	18.04	97.26	18.47	99
100	98.48	17.36	98.40	17.79	98.33	18.22	98.25	18.65	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	80 Deg.		79¾ Deg.		79½ Deg.		79¼ Deg.		

Distance.	11 Deg.		11¼ Deg.		11½ Deg.		11¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.98	0.19	0.98	0.20	0.98	0.20	0.98	0.20	1
2	1.96	0.38	1.96	0.39	1.96	0.40	1.96	0.41	2
3	2.94	0.57	2.94	0.59	2.94	0.60	2.94	0.61	3
4	3.93	0.76	3.92	0.78	3.92	0.80	3.92	0.82	4
5	4.91	0.95	4.90	0.98	4.90	1.00	4.90	1.02	5
6	5.89	1.14	5.88	1.17	5.88	1.20	5.87	1.22	6
7	6.87	1.34	6.87	1.37	6.86	1.40	6.85	1.43	7
8	7.85	1.53	7.85	1.56	7.84	1.59	7.83	1.63	8
9	8.83	1.72	8.83	1.76	8.82	1.79	8.81	1.83	9
10	9.82	1.91	9.81	1.95	9.80	1.99	9.79	2.04	10
11	10.80	2.10	10.79	2.15	10.78	2.19	10.77	2.24	11
12	11.78	2.29	11.77	2.34	11.76	2.39	11.75	2.44	12
13	12.76	2.48	12.75	2.54	12.74	2.59	12.73	2.65	13
14	13.74	2.67	13.73	2.73	13.72	2.79	13.71	2.85	14
15	14.72	2.86	14.71	2.93	14.70	2.99	14.69	3.06	15
16	15.71	3.05	15.69	3.12	15.68	3.19	15.66	3.26	16
17	16.69	3.24	16.67	3.32	16.66	3.39	16.64	3.46	17
18	17.67	3.43	17.65	3.51	17.64	3.59	17.62	3.66	18
19	18.65	3.63	18.63	3.71	18.62	3.79	18.60	3.87	19
20	19.63	3.82	19.62	3.90	19.60	3.99	19.58	4.07	20
21	20.61	4.01	20.60	4.10	20.58	4.19	20.56	4.28	21
22	21.60	4.20	21.58	4.29	21.56	4.39	21.54	4.48	22
23	22.58	4.39	22.56	4.49	22.54	4.59	22.52	4.68	23
24	23.56	4.58	23.54	4.68	23.52	4.78	23.50	4.89	24
25	24.54	4.77	24.52	4.88	24.50	4.98	24.48	5.09	25
26	25.52	4.96	25.50	5.07	25.48	5.18	25.46	5.30	26
27	26.50	5.15	26.48	5.27	26.46	5.38	26.43	5.50	27
28	27.49	5.34	27.46	5.46	27.44	5.58	27.41	5.70	28
29	28.47	5.53	28.44	5.66	28.42	5.78	28.39	5.91	29
30	29.45	5.72	29.42	5.85	29.40	5.98	29.37	6.11	30
31	30.43	5.92	30.40	6.05	30.38	6.18	30.35	6.31	31
32	31.41	6.11	31.39	6.24	31.36	6.38	31.33	6.52	32
33	32.39	6.30	32.37	6.44	32.34	6.58	32.31	6.72	33
34	33.38	6.49	33.35	6.63	33.32	6.78	33.29	6.92	34
35	34.36	6.68	34.33	6.83	34.30	6.98	34.27	7.13	35
36	35.34	6.87	35.31	7.02	35.28	7.18	35.25	7.33	36
37	36.32	7.06	36.29	7.22	36.26	7.38	36.22	7.53	37
38	37.30	7.25	37.27	7.41	37.24	7.58	37.20	7.74	38
39	38.28	7.44	38.25	7.61	38.22	7.78	38.18	7.94	39
40	39.27	7.63	39.23	7.80	39.20	7.97	39.16	8.15	40
41	40.25	7.82	40.21	8.00	40.18	8.17	40.14	8.35	41
42	41.23	8.01	41.19	8.19	41.16	8.37	41.12	8.55	42
43	42.21	8.20	42.17	8.39	42.14	8.57	42.10	8.76	43
44	43.19	8.40	43.15	8.58	43.12	8.77	43.08	8.96	44
45	44.17	8.59	44.14	8.78	44.10	8.97	44.06	9.16	45
46	45.15	8.78	45.12	8.97	45.08	9.17	45.04	9.37	46
47	46.14	8.97	46.10	9.17	46.06	9.37	46.02	9.57	47
48	47.12	9.16	47.08	9.36	47.04	9.57	46.99	9.78	48
49	48.10	9.35	48.06	9.56	48.02	9.77	47.97	9.98	49
50	49.08	9.54	49.04	9.75	49.00	9.97	48.95	10.18	50
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance.	79 Deg.		78¾ Deg.		78½ Deg.		78¼ Deg.		Distance.

Distance	11 Deg. Lat.	11 Deg. Dep.	11¼ Deg. Lat.	11¼ Deg. Dep.	11½ Deg. Lat.	11½ Deg. Dep.	11¾ Deg. Lat.	11¾ Deg. Dep.	Distance
51	50.06	9.73	50.02	9.95	49.98	10.17	49.93	10.39	51
52	51.04	9.92	51.00	10.14	50.96	10.37	50.91	10.59	52
53	52.03	10.11	51.98	10.34	51.94	10.57	51.89	10.79	53
54	53.01	10.30	52.96	10.53	52.92	10.77	52.87	11.00	54
55	53.99	10.49	53.94	10.73	53.90	10.97	53.85	11.20	55
56	54.97	10.69	54.92	10.93	54.88	11.16	54.83	11.40	56
57	55.95	10.88	55.90	11.12	55.86	11.36	55.81	11.61	57
58	56.93	11.07	56.89	11.32	56.84	11.56	56.78	11.81	58
59	57.92	11.26	57.87	11.51	57.82	11.76	57.76	12.01	59
60	58.90	11.45	58.85	11.71	58.80	11.96	58.74	12.22	60
61	59.88	11.64	59.83	11.90	59.78	12.16	59.72	12.42	61
62	60.86	11.83	60.81	12.10	60.76	12.36	60.70	12.63	62
63	61.84	12.02	61.79	12.29	61.74	12.56	61.68	12.83	63
64	62.82	12.21	62.77	12.49	62.72	12.76	62.66	13.03	64
65	63.81	12.40	63.75	12.68	63.70	12.96	63.64	13.24	65
66	64.79	12.59	64.73	12.88	64.68	13.16	64.62	13.44	66
67	65.77	12.78	65.71	13.07	65.66	13.36	65.60	13.64	67
68	66.75	12.98	66.69	13.27	66.63	13.56	66.58	13.85	68
69	67.73	13.17	67.67	13.46	67.61	13.76	67.55	14.05	69
70	68.71	13.36	68.66	13.66	68.59	13.96	68.53	14.25	70
71	69.70	13.55	69.64	13.85	69.57	14.16	69.51	14.46	71
72	70.68	13.74	70.62	14.05	70.55	14.35	70.49	14.66	72
73	71.66	13.93	71.60	14.24	71.53	14.55	71.47	14.87	73
74	72.64	14.12	72.58	14.44	72.51	14.75	72.45	15.07	74
75	73.62	14.31	73.56	14.63	73.49	14.95	73.43	15.27	75
76	74.60	14.50	74.54	14.83	74.47	15.15	74.41	15.48	76
77	75.59	14.69	75.52	15.02	75.45	15.35	75.39	15.68	77
78	76.57	14.88	76.50	15.22	76.43	15.55	76.37	15.88	78
79	77.55	15.07	77.48	15.41	77.41	15.75	77.34	16.09	79
80	78.53	15.26	78.46	15.61	78.39	15.95	78.32	16.29	80
81	79.51	15.46	79.44	15.80	79.37	16.15	79.30	16.49	81
82	80.49	15.65	80.42	16.00	80.35	16.35	80.28	16.70	82
83	81.48	15.84	81.41	16.19	81.33	16.55	81.26	16.90	83
84	82.46	16.03	82.39	16.39	82.31	16.75	82.24	17.11	84
85	83.44	16.22	83.37	16.58	83.29	16.95	83.22	17.31	85
86	84.42	16.41	84.35	16.78	84.27	17.15	84.20	17.51	86
87	85.40	16.60	85.33	16.97	85.25	17.35	85.18	17.72	87
88	86.38	16.79	86.31	17.17	86.23	17.54	86.16	17.92	88
89	87.36	16.98	87.29	17.36	87.21	17.74	87.14	18.12	89
90	88.35	17.17	88.27	17.56	88.19	17.94	88.11	18.33	90
91	89.33	17.36	89.25	17.75	89.17	18.14	89.09	18.53	91
92	90.31	17.55	90.23	17.95	90.15	18.34	90.07	18.74	92
93	91.29	17.75	91.21	18.14	91.13	18.54	91.05	18.94	93
94	92.27	17.94	92.19	18.34	92.11	18.74	92.03	19.14	94
95	93.25	18.13	93.17	18.53	93.09	18.94	93.01	19.35	95
96	94.24	18.32	94.16	18.73	94.07	19.14	93.99	19.55	96
97	95.22	18.51	95.14	18.92	95.05	19.34	94.97	19.75	97
98	96.20	18.70	96.12	19.12	96.03	19.54	95.95	19.96	98
99	97.18	18.89	97.10	19.31	97.01	19.74	96.93	20.16	99
100	98.16	19.08	98.08	19.51	97.99	19.94	97.90	20.36	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	79 Deg.		78¾ Deg.		78½ Deg.		78¼ Deg.		

Distance.	12 Deg Lat.	12 Deg Dep.	12¼ Deg. Lat.	12¼ Deg. Dep.	12½ Deg. Lat.	12½ Deg. Dep.	12¾ Deg. Lat.	12¾ Deg. Dep.	Distance.
1	0.98	0.21	0.98	0.21	0.98	0.22	0.98	0.22	1
2	1.96	0.42	1.95	0.42	1.95	0.43	1.95	0.44	2
3	2.93	0.62	2.93	0.64	2.93	0.65	2.93	0.66	3
4	3.91	0.83	3.91	0.85	3.91	0.87	3.90	0.88	4
5	4.89	1.04	4.89	1.06	4.88	1.08	4.88	1.10	5
6	5.87	1.25	5.86	1.27	5.86	1.30	5.85	1.32	6
7	6.85	1.46	6.84	1.49	6.83	1.52	6.83	1.54	7
8	7.83	1.66	7.82	1.70	7.81	1.73	7.80	1.77	8
9	8.80	1.87	8.80	1.91	8.79	1.95	8.78	1.99	9
10	9.78	2.08	9.77	2.12	9.76	2.16	9.75	2.21	10
11	10.76	2.29	10.75	2.33	10.74	2.38	10.73	2.43	11
12	11.74	2.49	11.73	2.55	11.72	2.60	11.70	2.65	12
13	12.72	2.70	12.70	2.76	12.69	2.81	12.68	2.87	13
14	13.69	2.91	13.68	2.97	13.67	3.03	13.65	3.09	14
15	14.67	3.12	14.66	3.18	14.64	3.25	14.63	3.31	15
16	15.65	3.33	15.64	3.39	15.62	3.46	15.61	3.53	16
17	16.63	3.53	16.61	3.61	16.60	3.68	16.58	3.75	17
18	17.61	3.74	17.59	3.82	17.57	3.90	17.56	3.97	18
19	18.58	3.95	18.57	4.03	18.55	4.11	18.53	4.19	19
20	19.56	4.16	19.54	4.24	19.53	4.33	19.51	4.41	20
21	20.54	4.37	20.52	4.46	20.50	4.55	20.48	4.63	21
22	21.52	4.57	21.50	4.67	21.48	4.76	21.46	4.86	22
23	22.50	4.78	22.48	4.88	22.45	4.98	22.43	5.08	23
24	23.48	4.99	23.45	5.09	23.43	5.19	23.41	5.30	24
25	24.45	5.20	24.43	5.30	24.41	5.41	24.38	5.52	25
26	25.43	5.41	25.41	5.52	25.38	5.63	25.36	5.74	26
27	26.41	5.61	26.39	5.73	26.36	5.84	26.33	5.96	27
28	27.39	5.82	27.36	5.94	27.34	6.06	27.31	6.18	28
29	28.37	6.03	28.34	6.15	28.31	6.28	28.28	6.40	29
30	29.34	6.24	29.32	6.37	29.29	6.49	29.26	6.62	30
31	30.32	6.45	30.29	6.58	30.27	6.71	30.24	6.84	31
32	31.30	6.65	31.27	6.79	31.24	6.93	31.21	7.06	32
33	32.28	6.86	32.25	7.00	32.22	7.14	32.19	7.28	33
34	33.26	7.07	33.23	7.21	33.19	7.36	33.16	7.50	34
35	34.24	7.28	34.20	7.43	34.17	7.58	34.14	7.72	35
36	35.21	7.48	35.18	7.64	35.15	7.79	35.11	7.95	36
37	36.19	7.69	36.16	7.85	36.12	8.01	36.09	8.17	37
38	37.17	7.90	37.13	8.06	37.10	8.22	37.06	8.39	38
39	38.15	8.11	38.11	8.27	38.08	8.44	38.04	8.61	39
40	39.13	8.32	39.09	8.49	39.05	8.66	39.01	8.83	40
41	40.10	8.52	40.07	8.70	40.03	8.87	39.99	9.05	41
42	41.08	8.73	41.04	8.91	41.00	9.09	40.96	9.27	42
43	42.06	8.94	47.02	9.12	41.98	9.31	41.94	9.49	43
44	43.04	9.15	43.00	9.34	42.96	9.52	42.92	9.71	44
45	44.02	9.36	43.98	9.55	43.93	9.74	43.89	9.93	45
46	44.99	9.56	44.95	9.76	44.91	9.96	44.87	10.15	46
47	45.97	9.77	45.93	9.97	45.89	10.17	45.84	10.37	47
48	46.95	9.98	46.91	10.18	46.86	10.39	46.82	10.59	48
49	47.93	10.19	47.88	10.40	47.84	10.61	47.79	10.81	49
50	48.91	10.40	48.86	10.61	48.81	10.82	48.77	11.03	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	78 Deg.		77¾ Deg.		77½ Deg.		77¼ Deg.		

Distance.	12 Deg. Lat.	12 Deg. Dep.	12¼ Deg. Lat.	12¼ Deg. Dep.	12½ Deg. Lat.	12½ Deg. Dep.	12¾ Deg. Lat.	12¾ Deg. Dep.	Distance.
51	49.89	10.60	49.84	10.82	49.79	11.04	49.74	11.26	51
52	50.86	10.81	50.82	11.03	50.77	11.25	50.72	11.48	52
53	51.84	11.02	51.79	11.25	51.74	11.47	51.69	11.70	53
54	52.82	11.23	52.77	11.46	52.72	11.69	52.67	11.92	54
55	53.80	11.44	53.75	11.67	53.70	11.90	53.64	12.14	55
56	54.78	11.64	54.72	11.88	54.67	12.12	54.62	12.36	56
57	55.75	11.85	55.70	12.09	55.65	12.34	55.59	12.58	57
58	56.73	12.06	56.68	12.31	56.63	12.55	56.57	12.80	58
59	57.71	12.27	57.66	12.52	57.60	12.77	57.55	13.02	59
60	58.69	12.47	58.63	12.73	58.58	12.99	58.52	13.24	60
61	59.67	12.68	59.61	12.94	59.55	13.20	59.50	13.46	61
62	60.65	12.89	60.59	13.16	60.53	13.42	60.47	13.68	62
63	61.62	13.10	61.57	13.37	61.51	13.64	61.45	13.90	63
64	62.60	13.31	62.54	13.58	62.48	13.85	62.42	14.12	64
65	63.58	13.51	63.52	13.79	63.46	14.07	63.40	14.35	65
66	64.56	13.72	64.50	14.00	64.44	14.29	64.37	14.57	66
67	65.54	13.93	65.47	14.22	65.41	14.50	65.35	14.79	67
68	66.51	14.14	66.45	14.43	66.39	14.72	66.32	15.01	68
69	67.49	14.35	67.43	14.64	67.36	14.93	67.30	15.23	69
70	68.47	14.55	68.41	14.85	68.34	15.15	68.27	15.45	70
71	69.45	14.76	69.38	15.06	69.32	15.37	69.25	15.67	71
72	70.43	14.97	70.36	15.28	70.29	15.58	70.22	15.89	72
73	71.40	15.18	71.34	15.49	71.27	15.80	71.20	16.11	73
74	72.38	15.39	72.32	15.70	72.25	16.02	72.18	16.33	74
75	73.36	15.59	73.29	15.91	73.22	16.23	73.15	16.55	75
76	74.34	15.80	74.27	16.13	74.20	16.45	74.13	16.77	76
77	75.32	16.01	75.25	16.34	75.17	16.67	75.10	16.99	77
78	76.30	16.22	76.22	16.55	76.15	16.88	76.08	17.21	78
79	77.27	16.43	77.20	16.76	77.13	17.10	77.05	17.44	79
80	78.25	16.63	78.18	16.97	78.10	17.32	78.03	17.66	80
81	79.23	16.84	79.16	17.19	79.08	17.53	79.00	17.88	81
82	80.21	17.05	80.13	17.40	80.06	17.75	79.98	18.10	82
83	81.19	17.26	81.11	17.61	81.03	17.96	80.95	18.32	83
84	82.16	17.46	82.09	17.82	82.01	18.18	81.93	18.54	84
85	83.14	17.67	83.06	18.04	82.99	18.40	82.90	18.76	85
86	84.12	17.88	84.04	18.25	83.96	18.61	83.88	18.98	86
87	85.10	18.09	85.02	18.46	84.94	18.83	84.85	19.20	87
88	86.08	18.30	86.00	18.67	85.91	19.05	85.83	19.42	88
89	87.06	18.50	86.97	18.88	86.89	19.26	86.81	19.64	89
90	88.03	18.71	87.95	19.10	87.87	19.48	87.78	19.86	90
91	89.01	18.92	88.93	19.31	88.84	19.70	88.76	20.08	91
92	89.99	19.13	89.91	19.52	89.82	19.91	89.73	20.30	92
93	90.97	19.34	90.88	19.73	90.80	20.13	90.71	20.52	93
94	91.95	19.54	91.86	19.94	91.77	20.35	91.68	20.75	94
95	92.92	19.75	92.84	20.16	92.75	20.56	92.66	20.97	95
96	93.90	19.96	93.81	20.37	93.72	20.78	93.63	21.19	96
97	94.88	20.17	94.79	20.58	94.70	20.99	94.61	21.41	97
98	95.86	20.38	95.77	20.79	95.68	21.21	95.58	21.63	98
99	96.84	20.58	96.75	21.01	96.65	21.43	96.56	21.85	99
100	97.81	20.79	97.72	21.22	97.63	21.64	97.53	22.07	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	78 Deg.		77¾ Deg.		77½ Deg.		77¼ Deg.		

Distance.	13 Deg.		13¼ Deg.		13½ Deg.		13¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.97	0.23	0.97	0.23	0.97	0.23	0.97	0.24	1
2	1.95	0.45	1.95	0.46	1.95	0.47	1.94	0.48	2
3	2.92	0.67	2.92	0.69	2.92	0.70	2.91	0.71	3
4	3.90	0.90	3.89	0.92	3.89	0.93	3.89	0.95	4
5	4.87	1.12	4.87	1.15	4.86	1.17	4.86	1.19	5
6	5.85	1.35	5.84	1.38	5.83	1.40	5.83	1.43	6
7	6.82	1.57	6.81	1.60	6.81	1.63	6.80	1.66	7
8	7.80	1.80	7.79	1.83	7.78	1.87	7.77	1.90	8
9	8.77	2.02	8.76	2.06	8.75	2.10	8.74	2.14	9
10	9.74	2.25	9.73	2.29	9.72	2.33	9.71	2.38	10
11	10.72	2.47	10.71	2.52	10.70	2.57	10.68	2.61	11
12	11.69	2.70	11.68	2.75	11.67	2.80	11.66	2.85	12
13	12.67	2.92	12.65	2.98	12.64	3.03	12.63	3.09	13
14	13.64	3.15	13.63	3.21	13.61	3.27	13.60	3.33	14
15	14.62	3.37	14.60	3.44	14.59	3.50	14.57	3.57	15
16	15.59	3.60	15.57	3.67	15.56	3.74	15.54	3.80	16
17	16.57	3.82	16.55	3.90	16.53	3.97	16.51	4.04	17
18	17.54	4.05	17.52	4.13	17.50	4.20	17.48	4.28	18
19	18.51	4.27	18.49	4.35	18.48	4.44	18.46	4.52	19
20	19.49	4.50	19.47	4.58	19.45	4.67	19.43	4.75	20
21	20.46	4.72	20.44	4.81	20.42	4.90	20.40	4.99	21
22	21.44	4.95	21.41	5.04	21.39	5.14	21.37	5.23	22
23	22.41	5.17	22.39	5.27	22.36	5.37	22.34	5.47	23
24	23.38	5.40	23.36	5.50	23.34	5.60	23.31	5.70	24
25	24.36	5.62	24.33	5.73	24.31	5.84	24.28	5.94	25
26	25.33	5.85	25.31	5.96	25.28	6.07	25.25	6.18	26
27	26.31	6.07	26.28	6.19	26.25	6.30	26.23	6.42	27
28	27.28	6.30	27.25	6.42	27.23	6.54	27.20	6.66	28
29	28.26	6.52	28.23	6.65	28.20	6.77	28.17	6.89	29
30	29.23	6.75	29.20	6.88	29.17	7.00	29.14	7.13	30
31	30.21	6.97	30.17	7.11	30.14	7.24	30.11	7.37	31
32	31.18	7.20	31.15	7.33	31.12	7.47	31.08	7.61	32
33	32.15	7.42	32.12	7.56	32.09	7.70	32.05	7.84	33
34	33.13	7.65	33.09	7.79	33.06	7.94	33.03	8.08	34
35	34.10	7.87	34.07	8.02	34.03	8.17	34.00	8.32	35
36	35.08	8.10	35.04	8.25	35.01	8.40	34.97	8.56	36
37	36.05	8.32	36.02	8.48	35.98	8.64	35.94	8.79	37
38	37.03	8.55	36.99	8.71	36.95	8.87	36.91	9.03	38
39	38.00	8.77	37.96	8.94	37.92	9.10	37.88	9.27	39
40	38.97	9.00	38.94	9.17	38.89	9.34	38.85	9.51	40
41	39.95	9.22	39.91	9.40	39.87	9.57	39.83	9.75	41
42	40.92	9.45	40.88	9.63	40.84	9.80	40.80	9.98	42
43	41.90	9.67	41.86	9.86	41.81	10.04	41.77	10.22	43
44	42.87	9.90	42.83	19.08	42.78	10.27	42.74	10.46	44
45	43.85	10.12	43.80	10.31	43.76	10.51	43.71	10.70	45
46	44.82	10.35	44.78	10.54	44.73	10.74	44.68	10.93	46
47	45.80	10.57	45.75	10.77	45.70	10.97	45.65	11.17	47
48	46.77	10.80	46.72	11.00	46.67	11.21	46.62	11.41	48
49	47.74	11.02	47.70	11.23	47.65	11.44	47.60	11.65	49
50	48.72	11.25	48.67	11.46	48.62	11.67	48.57	11.88	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	77 Deg.		76¾ Deg.		76½ Deg.		76¼ Deg.		

Distance.	13 Deg.		13¼ Deg.		13½ Deg.		13¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.69	11.47	49.64	11.69	49.59	11.91	49.54	12.12	51
52	50.67	11.70	50.62	11.92	50.56	12.14	50.51	12.36	52
53	51.64	11.92	51.59	12.15	51.54	12.37	51.48	12.60	53
54	52.62	12.15	52.56	12.38	52.51	12.61	52.45	12.84	54
55	53.59	12.37	53.54	12.61	53.48	12.84	53.42	13.07	55
56	54.56	12.60	54.51	12.84	54.45	13.07	54.40	13.31	56
57	55.54	12.82	55.48	13.06	55.43	13.31	55.37	13.55	57
58	56.51	13.05	56.46	13.29	56.40	13.54	56.34	13.79	58
59	57.49	13.27	57.43	13.52	57.37	13.77	57.31	14.02	59
60	58.46	13.50	58.40	13.75	58.34	14.01	58.28	14.26	60
61	59.44	13.72	59.38	13.98	59.31	14.24	59.25	14.50	61
62	60.41	13.95	60.35	14.21	60.29	14.47	60.22	14.74	62
63	61.39	14.17	61.32	14.44	61.26	14.71	61.19	14.97	63
64	62.36	14.40	62.30	14.67	62.23	14.94	62.17	15.21	64
65	63.33	14.62	63.27	14.90	63.20	15.17	63.14	15.45	65
66	64.31	14.85	64.24	15.13	64.18	15.41	64.11	15.69	66
67	65.28	15.07	65.22	15.36	65.15	15.64	65.08	15.93	67
68	66.26	15.30	66.19	15.59	66.12	15.87	66.05	16.16	68
69	67.23	15.52	67.16	15.81	67.09	16.11	67.02	16.40	69
70	68.21	15.75	68.14	16.04	68.07	16.34	67.99	16.64	70
71	69.18	15.97	69.11	16.27	69.04	16.57	68.97	16.88	71
72	70.15	16.20	70.08	16.50	70.01	16.81	69.94	17.11	72
73	71.13	16.42	71.06	16.73	70.98	17.04	70.91	17.35	73
74	72.10	16.65	72.03	16.96	71.96	17.28	71.88	17.59	74
75	73.08	16.87	73.00	17.19	72.93	17.50	72.85	17.83	75
76	74.05	17.10	73.98	17.42	73.90	17.74	73.82	18.06	76
77	75.03	17.32	74.95	17.65	74.87	17.98	74.79	18.30	77
78	76.00	17.55	75.92	17.88	75.84	18.21	75.76	18.54	78
79	76.98	17.77	76.90	18.11	76.82	18.44	76.74	18.78	79
80	77.95	18.00	77.87	18.34	77.79	18.68	77.71	19.01	80
81	78.92	18.22	78.84	18.57	78.76	18.91	78.68	19.25	81
82	79.90	18.45	79.82	18.79	79.73	19.14	79.65	19.49	82
83	80.87	18.67	80.79	19.02	80.71	19.38	80.62	19.73	83
84	81.85	18.90	81.76	19.25	81.68	19.61	81.59	19.97	84
85	82.82	19.12	82.74	19.48	82.65	19.84	82.56	20.20	85
86	83.80	19.35	83.71	19.71	83.62	20.08	83.54	20.44	86
87	84.77	19.57	84.68	19.94	84.60	20.31	84.51	20.68	87
88	85.74	19.80	85.66	20.17	85.57	20.54	85.48	20.92	88
89	86.72	20.02	86.63	20.40	86.54	20.78	86.45	21.15	89
90	87.69	20.25	87.60	20.63	87.51	21.01	87.42	21.39	90
91	88.67	20.47	88.58	20.86	88.49	21.24	88.39	21.63	91
92	89.64	20.70	89.55	21.09	89.46	21.48	89.36	21.87	92
93	90.62	20.92	90.52	21.32	90.43	21.71	90.33	22.10	93
94	91.59	21.15	91.50	21.54	91.40	21.94	91.31	22.34	94
95	92.57	21.37	92.47	21.77	92.38	22.18	92.28	22.58	95
96	93.54	21.60	93.44	22.00	93.35	22.41	93.25	22.82	96
97	94.51	21.82	94.42	22.23	94.32	22.64	94.22	23.06	97
98	95.49	22.05	95.39	22.46	95.29	22.88	95.19	23.29	98
99	96.46	22.27	96.36	22.69	96.26	23.11	96.16	23.53	99
100	97.44	22.50	97.34	22.92	97.24	23.34	97.13	23.77	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	77 Deg.		76¾ Deg.		76½ Deg.		76¼ Deg.		

Distance.	14 Deg.		14¼ Deg.		14½ Deg.		14¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.97	0.24	0.97	0.25	0.97	0.25	0.97	0.25	1
2	1.94	0.48	1.94	0.49	1.94	0.50	1.93	0.51	2
3	2.91	0.73	2.91	0.74	2.90	0.75	2.90	0.76	3
4	3.88	0.97	3.88	0.98	3.87	1.00	3.87	1.02	4
5	4.85	1.21	4.85	1.23	4.84	1.25	4.84	1.27	5
6	5.82	1.45	5.82	1.48	5.81	1.50	5.80	1.53	6
7	6.79	1.69	6.78	1 72	6.78	1.75	6.77	1.78	7
8	7.76	1.94	7.75	1.97	7.75	2.00	7.74	2.04	8
9	8.73	2.18	8.72	2.22	8.71	2.25	8.70	2.29	9
10	9.70	2.42	9.69	2.46	9.68	2.50	9.67	2.55	10
11	10.67	2.66	10.66	2.71	10.65	2.75	10.64	2.80	11
12	11.64	2.90	11.63	2.95	11.62	3.00	11.60	3.06	12
13	12.61	3.15	12.60	3.20	12.59	3.25	12.57	3.31	13
14	13.58	3.39	13.57	3.45	13.55	3.51	13.54	3.56	14
15	14.55	3.63	14.54	3.69	14.52	3.76	14.51	3.82	15
16	15.52	3.87	15.51	3.94	15.49	4.01	15.47	4.07	16
17	16.50	4.11	16.48	4.18	16.46	4.26	16.44	4.33	17
18	17.47	4.35	17.45	4.43	17.43	4.51	17.41	4.58	18
19	18.44	4.60	18.42	4.68	18.39	4.76	18.37	4.84	19
20	19.41	4.84	19.38	4.92	19.36	5.01	19.34	5.09	20
21	20.38	5.08	20.35	5.17	20.33	5.26	20.31	5.35	21
22	21.35	5.32	21.32	5.42	21.30	5.51	21.28	5.60	22
23	22.32	5.56	22.29	5.66	22.27	5.76	22.24	5.86	23
24	23.99	5.81	23.26	5.91	23.24	6.01	23.21	6.11	24
25	24.26	6.05	24.23	6.15	24.20	6.26	24.18	6.37	25
26	25.23	6.29	25.20	6.40	25.17	6.51	25.14	6.62	26
27	26.20	6.53	26.17	6.65	26.14	6.76	26.11	6.87	27
28	27.17	6.77	27.14	6.89	27.11	7.01	27.08	7.13	28
29	28.14	7.02	28.11	7.14	28.08	7.26	28.04	7.38	29
30	29.11	7.26	29.08	7.38	29.04	7.51	29.01	7.64	30
31	30.08	7.50	30.05	7.63	30.01	7.76	29.98	7.89	31
32	31.05	7.74	31.02	7.88	30.98	8.01	30.95	8.15	32
33	32.02	7.98	31.98	8.12	31.95	8.26	31.91	8.40	33
34	32.99	8.23	32.95	8.37	32.92	8.51	32.88	8.66	34
35	33.96	8.47	33.92	8.62	33.89	8.76	33.85	8.91	35
36	34.93	8.71	34.89	8.86	34.85	9.01	34.81	9.17	36
37	35.90	8.95	35.86	9.11	35.82	9.26	35.78	9.42	37
38	36.87	9.19	36.83	9.35	36.79	9.51	36.75	9.67	38
39	37.84	9.44	37.80	9.60	37.76	9.76	37.71	9.93	39
40	38.81	9.68	38.77	9.85	38.73	10.02	38.68	10.18	40
41	39.78	9.92	39.74	10.09	39.69	10.27	39.65	10.44	41
42	40.75	10.16	40.71	10.34	40.66	10.52	40.62	10.69	42
43	41.72	10.40	41.68	10.58	41.63	10.77	41.58	10.95	43
44	42.69	10.64	42.65	10.83	42.60	11.02	42.55	11.20	44
45	43.66	10.89	43.62	11.08	43.57	11.27	43.52	11.46	45
46	44.63	11.13	44.58	11.32	44.53	11.52	44.48	11.71	46
47	45.60	11.37	45.55	11.57	45.50	11.77	45.45	11.97	47
48	46.57	11.61	46.52	11.82	46.47	12.02	46.42	12.22	48
49	47.54	11.85	47.49	12.06	47.44	12.27	47.39	12.48	49
50	48.51	12.10	48.46	12.31	48.41	12.52	48.35	12.73	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	76 Deg.		75¾ Deg.		75½ Deg.		75¼ Deg.		

Distance.	14 Deg. Lat.	14 Deg. Dep.	14¼ Deg. Lat.	14¼ Deg. Dep.	14½ Deg. Lat.	14½ Deg. Dep.	14¾ Deg. Lat.	14¾ Deg. Dep.	Distance.
51	49.49	12.34	49.43	12.55	49.38	12.77	49.32	12.98	51
52	50.46	12.58	50.40	12.80	50.34	13.02	50.29	13.24	52
53	51.43	12.82	51.37	13.05	51.31	13.27	51.25	13.49	53
54	52.40	13.06	52.34	13.29	52.28	13.52	52.22	13.75	54
55	53.37	13.31	53.31	13.54	53.25	13.77	53.19	14.00	55
56	54.34	13.55	54.28	13.78	54.22	14.02	54.15	14.26	56
57	55.31	13.79	55.25	14.03	55.18	14.27	55.12	14.51	57
58	56.28	14.03	56.22	14.28	56.15	14.52	56.09	14.77	58
59	57.25	14.27	57.18	14.52	57.12	14.77	57.06	15.02	59
60	58.22	14.52	58.15	14.77	58.09	15.02	58.02	15.28	60
61	59.19	14.76	59.12	15.02	59.06	15.27	58.99	15.53	61
62	60.16	15.00	60.09	15.26	60.03	15.52	59.96	15.79	62
63	61.13	15.24	61.06	15.51	60.99	15.77	60.92	16.04	63
64	62.10	15.48	62.03	15.75	61.96	16.02	61.89	16.29	64
65	63.07	15.72	63.00	16.00	62.93	16.27	62.86	16.55	65
66	64.04	15.97	63.97	16.25	63.90	16.53	63.83	16.80	66
67	65.01	16.21	64.94	16.49	64.87	16.78	64.79	17.06	67
68	65.98	16.45	65.91	16.74	65.83	17.03	65.76	17.31	68
69	66.95	16.69	66.88	16.98	66.80	17.28	66.73	17.57	69
70	67.92	16.93	67.85	17.23	67.77	17.53	67.69	17.82	70
71	68.89	17.18	68.82	17.48	68.74	17.78	68.66	18.08	71
72	69.86	17.42	69.78	17.72	69.71	18.03	69.63	18.33	72
73	70.83	17.66	70.75	17.97	70.67	18.28	70.59	18.59	73
74	71.80	17.90	71.72	18.22	71.64	18.53	71.56	18.84	74
75	72.77	18.14	72.69	18.46	72.61	18.78	72.53	19.10	75
76	73.74	18.39	73.66	18.71	73.58	19.03	73.50	19.35	76
77	74.71	18.63	74.63	18.95	74.55	19.28	74.46	19.60	77
78	75.68	18.87	75.60	19.20	75.52	19.53	75.43	19.86	78
79	76.65	19.11	76.57	19.45	76.48	19.78	76.40	20.11	79
80	77.62	19.35	77.54	19.69	77.45	20.03	77.36	20.37	80
81	78.59	19.60	78.51	19.94	78.42	20.28	78.33	20.62	81
82	79.56	19.84	79.48	20.18	79.39	20.53	79.30	20.88	82
83	80.53	20.08	80.45	20.43	80.36	20.78	80.26	21.13	83
84	81.50	20.32	81.42	20.68	81.32	21.03	81.23	21.39	84
85	82.48	20.56	82.38	20.92	82.29	21.28	82.20	21.64	85
86	83.45	20.81	83.35	21.17	83.26	21.53	83.17	21.90	86
87	84.42	21.05	84.32	21.42	84.23	21.78	84.13	22.15	87
88	85.39	21.29	85.29	21.66	85.20	22.03	85.10	22.41	88
89	86.36	21.53	86.26	21.91	86.17	22.28	86.07	22.66	89
90	87.33	21.77	87.23	22.15	87.13	22.53	87.03	22.91	90
91	88.30	22.01	88.20	22.40	88.10	22.78	88.00	23.17	91
92	89.27	22.26	89.17	22.65	89.07	23.04	88.97	23.42	92
93	90.24	22.50	90.14	22.89	90.04	23.29	89.94	23.68	93
94	91.21	22.74	91.11	23.14	91.01	23.54	90.90	23.93	94
95	92.18	22.98	92.08	23.38	91.97	23.79	91.87	24.19	95
96	93.15	23.22	93.05	23.63	92.94	24.04	92.84	24.44	96
97	94.12	23.47	94.02	23.88	93.91	24.29	93.80	24.70	97
98	95.09	23.71	94.98	24.12	94.88	24.54	94.77	24.95	98
99	96.06	23.9[illegible]	95.95	24.37	95.85	24.79	95.74	25.21	99
100	97.03	24.19	96.92	24.62	96.81	25.04	96.70	25.46	100
Distance.	76 Deg. Dep.	76 Deg. Lat.	75¾ Deg Dep.	75¾ Deg Lat.	75½ Deg. Dep.	75½ Deg. Lat.	75¼ Deg Dep.	75¼ Deg Lat.	Distance.

Distance.	15 Deg.		15¼ Deg.		15½ Deg.		15¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.97	0.26	0.96	0.26	0.96	0.27	0.96	0.27	1
2	1.93	0.52	1.93	0.53	1.93	0.53	1.92	0.54	2
3	2.90	0.78	2.89	0.79	2.89	0.80	2.89	0.81	3
4	3.86	1.04	3.86	1.05	3.85	1.07	3.85	1.09	4
5	4.83	1.29	4.82	1.32	4.82	1.34	4.81	1.36	5
6	5.80	1.55	5.79	1.58	5.78	1.60	5.77	1.63	6
7	6.76	1.81	6.75	1.84	6.75	1.87	6.74	1.90	7
8	7.73	2.07	7.72	2.10	7.71	2.14	7.70	2.17	8
9	8.69	2.33	8.68	2.37	8.67	2.41	8.66	2.44	9
10	9.66	2.59	9.65	2.63	9.64	2.67	9.62	2.71	10
11	10.63	2.85	10.61	2.89	10.60	2.94	10.59	2.99	11
12	11.59	3.11	11.58	3.16	11.56	3.21	11.55	3.26	12
13	12.56	3.36	12.54	3.42	12.53	3.47	12.51	3.53	13
14	13.52	3.62	13.51	3.68	13.49	3.74	13.47	3.80	14
15	14.49	3.88	14.47	3.95	14.45	4.01	14.44	4.07	15
16	15.45	4.14	15.44	4.21	15.42	4.28	15.40	4.34	16
17	16.42	4.40	16.40	4.47	16.38	4.54	16.36	4.61	17
18	17.39	4.66	17.37	4.73	17.35	4.81	17.32	4.89	18
19	18.35	4.92	18.33	5.00	18.31	5.08	18.29	5.16	19
20	19.32	5.18	19.30	5.26	19.27	5.34	19.25	5.43	20
21	20.28	5.44	20.26	5.52	20.24	5.61	20.21	5.70	21
22	21.25	5.69	21.23	5.79	21.20	5.88	21.17	5.97	22
23	22.22	5.95	22.19	6.05	22.16	6.15	22.14	6.24	23
24	23.18	6.21	23.15	6.31	23.13	6.41	23.10	6.51	24
25	24.15	6.47	24.12	6.58	24.09	6.68	24.06	6.79	25
26	25.11	6.73	25.08	6.84	25.05	6.95	25.02	7.06	26
27	26.08	6.99	26.05	7.10	26.02	7.22	25.99	7.33	27
28	27.05	7.25	27.01	7.36	26.98	7.48	26.95	7.60	28
29	28.01	7.51	27.98	7.63	27.95	7.75	27.91	7.87	29
30	28.98	7.76	28.94	7.89	28.91	8.02	28.87	8.14	30
31	29.94	8.02	29.91	8.15	29.87	8.28	29.84	8.41	31
32	30.91	8.28	30.87	8.42	30.84	8.55	30.80	8.69	32
33	31.88	8.54	31.84	8.68	31.80	8.82	31.76	8.96	33
34	32.84	8.80	32.80	8.94	32.76	9.09	32.72	9.23	34
35	33.81	9.06	33.77	9.21	33.73	9.35	33.69	9.50	35
36	34.77	9.32	34.73	9.47	34.69	9.62	34.65	9.77	36
37	35.74	9.58	35.70	9.73	35.65	9.89	35.61	10.04	37
38	36.71	9.84	36.66	10.00	36.62	10.16	36.57	10.31	38
39	37.67	10.09	37.63	10.26	37.58	10.42	37.54	10.59	39
40	38.64	10.35	38.59	10.52	38.55	10.69	38.50	10.86	40
41	39.60	10.61	39.56	10.78	39.51	10.96	39.46	11.13	41
42	40.57	10.87	40.52	11.05	40.47	11.22	40.42	11.40	42
43	41.53	11.13	41.49	11.31	41.44	11.49	41.39	11.67	43
44	42.50	11.39	42.45	11.57	42.40	11.76	42.35	11.94	44
45	43.47	11.65	43.42	11.84	43.36	12.03	43.31	12.21	45
46	44.43	11.91	44.38	12.10	44.33	12.29	44.27	12.49	46
47	45.40	12.16	45.35	12.36	45.29	12.56	45.24	12.76	47
48	46.36	12.42	46.31	12.63	46.25	12.83	46.20	13.03	48
49	47.33	12.68	47.27	12.89	47.22	13.09	47.16	13.30	49
50	48.30	12.94	48.24	13.15	48.18	13.36	48.12	13.57	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	75 Deg.		74¾ Deg.		74½ Deg.		74¼ Deg.		

Distance.	15 Deg.		15¼ Deg.		15½ Deg.		15¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.26	13.20	49.20	13.41	49.15	13.63	49.09	13.84	51
52	50.23	13.46	50.17	13.68	50.11	13.90	50.05	14.11	52
53	51.19	13.72	51.13	13.94	51.07	14.16	51.01	14.39	53
54	52.16	13.98	52.10	14.20	52.04	14.43	51.97	14.66	54
55	53.13	14.24	53.06	14.47	53.00	14.70	52.94	14.93	55
56	54.09	14.49	54.03	14.73	53.96	14.97	53.90	15.20	56
57	55.06	14.75	54.99	14.99	54.93	15.23	54.86	15.47	57
58	56.02	15.01	55.96	15.26	55.89	15.50	55.82	15.74	58
59	56.99	15.27	56.92	15.52	56.85	15.77	56.78	16.01	59
60	57.96	15.53	57.89	15.78	57.82	16.03	57.75	16.29	60
61	58.92	15.79	58.85	16.04	58.78	16.30	58.71	16.56	61
62	59.89	16.05	59.82	16.31	59.75	16.57	59.67	16.83	62
63	60.85	16.31	60.78	16.57	60.71	16.84	60.63	17.10	63
64	61.82	16.56	61.75	16.83	61.67	17.10	61.60	17.37	64
65	62.79	16.82	62.71	17.10	62.64	17.37	62.56	17.64	65
66	63.75	17.08	63.68	17.36	63.60	17.64	63.52	17.92	66
67	64.72	17.34	64.64	17.62	64.56	17.90	64.48	18.19	67
68	65.68	17.60	65.61	17.89	65.53	18.17	65.45	18.46	68
69	66.65	17.86	66.57	18.15	66.49	18.44	66.41	18.73	69
70	67.61	18.12	67.54	18.41	67.45	18.71	67.37	19.00	70
71	68.58	18.38	68.50	18.68	68.42	18.97	68.33	19.27	71
72	69.55	18.63	69.46	18.94	69.38	19.24	69.30	19.54	72
73	70.51	18.89	70.43	19.20	70.35	19.51	70.26	19.82	73
74	71.48	19.15	71.39	19.46	71.31	19.78	71.22	20.09	74
75	72.44	19.41	72.36	19.73	72.27	20.04	72.18	20.36	75
76	73.41	19.67	73.32	19.99	73.24	20.31	73.15	20.63	76
77	74.38	19.93	74.29	20.25	74.20	20.58	74.11	20.90	77
78	75.34	20.19	75.25	20.52	75.16	20.84	75.07	21.17	78
79	76.31	20.45	76.22	20.78	76.13	21.11	76.03	21.44	79
80	77.27	20.71	77.18	21.04	77.09	21.38	77.00	21.72	80
81	78.24	20.96	78.15	21.31	78.05	21.65	77.96	21.99	81
82	79.21	21.22	79.11	21.57	79.02	21.91	78.92	22.26	82
83	80.17	21.48	80.08	21.83	79.98	22.18	79.88	22.53	83
84	81.14	21.74	81.04	22.09	80.94	22.45	80.85	22.80	84
85	82.10	22.00	82.01	22.36	81.91	22.72	81.81	23.07	85
86	83.07	22.26	82.97	22.62	82.87	22.98	82.77	23.34	86
87	84.04	22.52	83.94	22.88	83.84	23.25	83.73	23.62	87
88	85.00	22.78	84.90	23.15	84.80	23.52	84.70	23.89	88
89	85.97	23.03	85.87	23.41	85.76	23.78	85.66	24.16	89
90	86.93	23.29	86.83	23.67	86.73	24.05	86.62	24.43	90
91	87.90	23.55	87.80	23.94	87.69	24.32	87.58	24.70	91
92	88.87	23.81	88.76	24.20	88.65	24.59	88.55	24.97	92
93	89.83	24.07	89.73	24.46	89.62	24.85	89.51	25.24	93
94	90.80	24.33	90.69	24.72	90.58	25.12	90.47	25.52	94
95	91.76	24.59	91.65	24.99	91.54	25.39	91.43	25.79	95
96	92.73	24.85	92.62	25.25	92.51	25.65	92.40	26.06	96
97	93.69	25.11	93.58	25.51	93.47	25.92	93.36	26.33	97
98	94.66	25.36	94.55	25.78	94.44	26.19	94.32	26.60	98
99	95.63	25.62	95.51	26.04	95.40	26.46	95.28	26.87	99
100	96.59	25.88	96.48	26.30	96.36	26.72	96.25	27.14	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	75 Deg.		74¾ Deg.		74½ Deg.		74¼ Deg.		

Distance.	16 Deg.		16¼ Deg.		16½ Deg.		16¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.96	0.28	0.96	0.28	0.96	0 28	0.96	0.29	1
2	1 92	0.55	1.92	0.56	1.92	6.57	1.92	0.58	2
3	2.88	0.83	2.88	0.84	2.88	0.85	2.87	0.86	3
4	3.85	1.10	3.84	1.12	3.84	1.14	3.83	1.15	4
5	4.81	1.38	4.80	1.40	4.79	1.42	4.79	1.44	5
6	5.77	1.65	5.76	1.68	5.75	1.70	5.75	1.73	6
7	6.73	1.93	6.72	1.96	6.71	1.99	6.70	2.02	7
8	7.69	2.21	7.68	2.24	7.67	2.27	7.66	2.31	8
9	8.65	2.48	8.61	2.52	8.63	2.56	8.62	2.59	9
10	9.61	2.76	9.60	2.80	9.59	2.84	9.58	2.88	10
11	10.57	3.03	10.56	3.08	10.55	3.12	10.53	3.17	11
12	11.54	3.31	11.52	3.36	11.51	3.41	11.49	3.46	12
13	12.50	3.58	12.48	3.64	12.46	3.69	12.45	3.75	13
14	13.46	3.86	13.44	3.92	13.42	3.98	13.41	4.03	14
15	14.42	4.13	14.40	4.20	14.38	4.26	14.36	4.32	15
16	15.38	4.41	15.36	4.48	15.34	4.54	15.32	4.61	16
17	16.34	4.69	16.32	4.76	16.30	4.83	16.28	4.90	17
18	17.30	4.96	17.28	5.04	17.26	5.11	17.24	5.19	18
19	18.26	5.24	18.24	5.32	18.22	5.40	18.19	5.48	19
20	19.23	5.51	19.20	5.60	19.18	5.68	19.15	5.76	20
21	20.19	5.79	20.16	5.88	20.14	5.96	20.11	6.05	21
22	21.15	6.06	21.12	6.16	21.09	6.25	21.07	6.34	22
23	22.11	6.34	22.08	6.44	22.05	6.53	22.02	6.63	23
24	23.07	6.62	23.04	6.72	23.01	6.82	22.98	6.92	24
25	24.03	6.89	24.00	7.00	23.97	7.10	23.94	7.20	25
26	24.99	7.17	24.96	7.28	24.93	7.38	24.90	7.49	26
27	25.95	7.44	25.92	7.56	25.89	7.67	25.85	7.78	27
28	26.92	7.72	26.88	7.84	26.85	7.95	26.81	8.07	28
29	27.88	7.99	27.84	8.11	27.81	8.24	27.77	8.36	29
30	28.84	8.27	28.80	8.39	28.76	8.52	28.73	8.65	30
31	29.80	8.54	29.76	8.67	29.72	8.80	29.68	8.93	31
32	30.76	8.82	30.72	8.95	30.68	9.09	30.64	9.22	32
33	31.72	9.10	31.68	9.23	31.64	9.37	31.60	9.51	33
34	32.68	9.37	32.64	9.51	32.60	9.66	32.56	9.80	34
35	33.64	9.65	33.60	9.79	33.56	9.94	33.51	10.09	35
36	34.61	9.92	34.56	10.07	34.52	10.22	34.47	10.38	36
37	35.57	10.20	35.52	10.35	35.48	10.51	35.43	10.66	37
38	36.53	10.47	36.48	10.63	36.44	10.79	36.39	10.95	38
39	37.49	10.75	37.44	10.91	37.39	11.08	37.35	11.24	39
40	38.45	11.03	38.40	11.19	38.35	11.36	38.30	11.53	40
41	39.41	11.30	39.36	11.47	39.31	11.64	39.26	11.82	41
42	40.37	11.58	40.32	11.75	40.27	11.93	40.22	12.10	42
43	41.33	11.85	41.28	12.03	41.23	12.21	41.18	12.39	43
44	42.30	12.13	42.24	12.31	42.19	12.50	42.13	12.68	44
45	43.26	12.40	43.20	12.59	43.15	12.78	43.09	12.97	45
46	44.22	12.68	44.16	12.87	44.11	13.06	44.05	13.26	46
47	45.18	12.95	45.12	13.15	45.06	13.35	45.01	13.55	47
48	46.14	13.23	46.08	13.43	46.02	13.63	45.96	13.83	48
49	47.10	13.51	47.04	13.71	46.98	13.92	46.92	14.19	49
50	48.06	13.78	48.00	13.99	47.94	14.20	47.88	14.41	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	74 Deg.		73¾ Deg.		73½ Deg.		73¼ Deg.		

Distance.	16 Deg.		16¼ Deg.		16½ Deg.		16¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.02	14.06	48.96	14.27	48.90	14.48	48.84	14.70	51
52	49.99	14.33	49.92	14.56	49.86	14.77	49.79	14.99	52
53	50.95	14.61	50.88	14.83	50.82	15.05	50.75	15.27	53
54	51.91	14.88	51.84	15.11	51.78	15.34	51.71	15.56	54
55	52.87	15.16	52.80	15.39	52.74	15.62	52.67	15.85	55
56	53.83	15.44	53.76	15.67	53.69	15.90	53.62	16.14	56
57	54.79	15.71	54.72	15.95	54.65	16.19	54.58	16.43	57
58	55.75	15.99	55.68	16.23	55.61	16.47	55.54	16.72	58
59	56.71	16.26	56.64	16.51	56.57	16.76	56.50	17.00	59
60	57.68	16.54	57.60	16.79	57.53	17.04	57.45	17.29	60
61	58.64	16.81	58.56	17.07	58.49	17.32	58.41	17.58	61
62	59.60	17.09	59.52	17.35	59.45	17.61	59.37	17.87	62
63	60.56	17.37	60.48	17.63	60.41	17.89	60.33	18.16	63
64	61.52	17.64	61.44	17.91	61.36	18.18	61.28	18.44	64
65	62.48	17.92	62.40	18.19	62.32	18.46	62.24	18.73	65
66	63.44	18.19	63.36	18.47	63.28	18.74	63.20	19.02	66
67	64.40	18.47	64.32	18.75	64.24	19.03	64.16	19.31	67
68	65.37	18.74	65.28	19.03	65.20	19.31	65.11	19.60	68
69	66.33	19.02	66.24	19.31	66.16	19.60	66.07	19.89	69
70	67.29	19.29	67.20	19.59	67.12	19.88	67.03	20.17	70
71	68.25	19.57	68.16	19.87	68.08	20.17	67.99	20.46	71
72	69.21	19.85	69.12	20.15	69.03	20.45	68.95	20.75	72
73	70.17	20.12	70.08	20.43	69.99	20.73	69.90	21.04	73
74	71.13	20.40	71.04	20.71	70.95	21.02	70.86	21.33	74
75	72.09	20.67	72.00	20.99	71.91	21.30	71.82	21.61	75
76	73.06	20.95	72.96	21.27	72.87	21.59	72.78	21.90	76
77	74.02	21.22	73.92	21.55	73.83	21.87	73.73	22.19	77
78	74.98	21.50	74.88	21.83	74.79	22.15	74.69	22.48	78
79	75.94	21.78	75.84	22.11	75.75	22.44	75.65	22.77	79
80	76.90	22.05	76.80	22.39	76.71	22.72	76.61	23.06	80
81	77.86	22.33	77.76	22.67	77.66	23.01	77.56	23.34	81
82	78.82	22.60	78.72	22.95	78.62	23.29	78.52	23.63	82
83	79.78	22.88	79.68	23.23	79.58	23.57	79.48	23.92	83
84	80.75	23.15	80.64	23.51	80.54	23.86	80.44	24.21	84
85	81.71	23.43	81.60	23.79	81.50	24.14	81.39	24.50	85
86	82.67	23.70	82.56	24.07	82.46	24.43	82.35	24.78	86
87	83.63	23.98	83.52	24.35	83.42	24.71	83.31	25.07	87
88	84.59	24.26	84.48	24.62	84.38	24.99	84.27	25.36	88
89	85.55	24.53	85.44	24.90	85.33	25.28	85.22	25.65	89
90	86.51	24.81	86.40	25.18	86.29	25.56	86.18	25.94	90
91	87.47	25.08	87.36	25.46	87.25	25.85	87.14	26.23	91
92	88.44	25.36	88.32	25.74	88.21	26.13	88.10	26.51	92
93	89.40	25.63	89.28	26.02	89.17	26.41	89.05	26.80	93
94	90.36	25.91	90.24	26.30	90.13	26.70	90.01	27.09	94
95	91.32	26.19	91.20	26.58	91.09	26.98	90.97	27.38	95
96	92.28	26.46	92.16	26.86	92.05	27.27	91.93	27.67	96
97	93.24	26.74	93.12	27.14	93.01	27.55	92.88	27.95	97
98	94.20	27.01	94.08	27.42	93.96	27.83	93.84	28.24	98
99	95.16	27.29	95.04	27.70	94.92	28.12	94.80	28.53	99
100	96.13	27.56	96.00	27.98	95.88	28.40	95.76	28.82	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	74 Deg.		73¾ Deg.		73½ Deg.		73¼ Deg.		

Distance.	17 Deg.		17¼ Deg.		17½ Deg.		17¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.96	0.29	0.95	0.30	0.95	0.30	0.95	0.30	1
2	1.91	0.58	1.91	0.59	1.91	0.60	1.90	0.61	2
3	2.87	0.88	2.87	0.89	2.86	0.90	2.86	0.91	3
4	3.83	1.17	3.82	1.19	3.81	1.20	3.81	1.22	4
5	4.78	1.46	4.78	1.48	4.77	1.50	4.76	1.52	5
6	5.74	1.75	5.73	1.78	5.72	1.80	5.71	1.83	6
7	6.69	2.05	6.69	2.08	6.68	2.10	6.67	2 13	7
8	7.65	2.34	7.64	2.37	7.63	2.41	7.62	2.44	8
9	8.61	2.63	8.60	2.67	8.58	2.71	8.57	2.74	9
10	9.56	2.92	9.55	2.97	9.54	3.01	9.52	3.05	10
11	10.52	3.22	10.51	3.26	10.49	3.31	10.48	3.35	11
12	11.48	3.51	11.46	3.56	11.44	3.61	11.43	3.66	12
13	12.43	3.80	12.42	3.85	12.40	3.91	12.38	3.96	13
14	13.39	4.09	13.37	4.15	13.35	4.21	13.33	4.27	14
15	14.34	4.39	14.33	4.45	14.31	4.51	14.29	4.57	15
16	15.30	4.68	15.28	4.74	15.26	4.81	15.24	4.88	16
17	16.26	4.97	16.24	5.04	16.21	5.11	16.19	5.18	17
18	17.21	5.26	17.19	5.34	17.17	5.41	17.14	5.49	18
19	18.17	5.56	18.15	5.63	18.12	5.71	18.10	5.79	19
20	19.13	5.85	19.10	5.93	19.07	6.01	19.05	6.10	20
21	20.08	6.14	20.06	6.23	20.03	6.31	20.00	6.40	21
22	21.04	6.43	21.01	6.52	20.98	6.62	20.95	6.71	22
23	21.99	6.72	21.97	6.82	21.94	6.92	21.91	7.01	23
24	22.95	7.02	22.92	7.12	22.89	7.22	22.86	7.32	24
25	23.91	7.31	23.88	7.41	23.84	7.52	23.81	7.62	25
26	24.86	7.60	24.83	7.71	24.80	7.82	24.76	7.93	26
27	25.82	7.89	25.79	8.01	25.75	8.12	25.71	8.23	27
28	26.78	8.19	26.74	8.30	26.70	8.42	26.67	8.54	28
29	27.73	8.48	27.70	8.60	27.66	8.72	27.62	8.84	29
30	28.69	8.77	28.65	8.90	28.61	9.02	28.57	9.15	30
31	29.65	9.06	29.61	9.19	29.57	9.32	29.52	9.45	31
32	30.60	9.36	30.56	9.49	30.52	9.62	30.48	9.76	32
33	31.56	9.65	31.52	9.79	31.47	9.92	31.43	10.06	33
34	32.51	9.94	32.47	10.08	32.43	10.22	32.38	10.37	34
35	33.47	10.23	33.43	10.38	33.38	10.52	33.33	10.67	35
36	34.43	10.53	34.38	10.68	34.33	10.83	34.29	10.98	36
37	35.38	10.82	35.34	10.97	35.29	11.13	35 24	11.28	37
38	36.34	11.11	36.29	11.27	36.24	11.43	36.19	11.58	38
39	37.30	11.40	37.25	11.57	37.19	11.73	37.14	11.89	39
40	38.25	11.69	38.20	11.86	38.15	12.03	38.10	12.19	40
41	39.21	11.99	39.16	12.16	39.10	12.33	39.05	12.50	41
42	40.16	12.28	40.11	12.45	40.06	12.63	40.00	12.80	42
43	41.12	12.57	41.07	12.75	41.01	12.93	40.95	13.11	43
44	42.08	12.86	42.02	13.05	41.96	13.23	41.91	13.41	44
45	43.03	13.16	42.98	13.34	42.92	13.53	42.86	13.72	45
46	43.99	13.45	43.93	13.64	43.87	13.83	43.81	14.02	46
47	44.95	13.74	44.89	13.94	44.82	14.13	44.76	14.33	47
48	45.90	14.03	45.84	14.23	45.78	14.43	45.71	14.63	48
49	46.86	14.33	46.80	14.53	46.73	14.73	46.67	14.94	49
50	47.82	14.62	47.75	14.83	47.69	15.04	47.62	15.24	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	73 Deg.		72¾ Deg.		72½ Deg.		72¼ Deg.		

Distance.	17 Deg.		17¼ Deg.		17½ Deg.		17¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	48.77	14.91	48.71	15.12	48.64	15.34	48.57	15.55	51
52	49.73	15.20	49.66	15.42	49.59	15.64	49.52	15.85	52
53	50.68	15.50	50.62	15.72	50.55	15.94	50.48	16.16	53
54	51.64	15.79	51.57	16.01	51.50	16.24	51.43	16.46	54
55	52.60	16.08	52.53	16.31	52.45	16.54	52.38	16.77	55
56	53.55	16.37	53.48	16.61	53.41	16.84	53.33	17.07	56
57	54.51	16.67	54.44	16.90	54.36	17.14	54.29	17.38	57
58	55.47	16.96	55.39	17.20	55.32	17.44	55.24	17.68	58
59	56.42	17.25	56.35	17.50	56.27	17.74	56.19	17.99	59
60	57.38	17.54	57.30	17.79	57.22	18.04	57.14	18.29	60
61	58.33	17.83	58.26	18.09	58.18	18.34	58.10	18.60	61
62	59.29	18.13	59.21	18.39	59.13	18.64	59.05	18.90	62
63	60.25	18.42	60.17	18.68	60.08	18.94	60.00	19.21	63
64	61.20	18.71	61.12	18.98	61.04	19.25	60.95	19.51	64
65	62.16	19.00	62.08	19.28	61.99	19.55	61.91	19.82	65
66	63.12	19.30	63.03	19.57	62.95	19.85	62.86	20.12	66
67	64.07	19.59	63.99	19.87	63.90	20.15	63.81	20.43	67
68	65.03	19.88	64.94	20.16	64.85	20.45	64.76	20.73	68
69	65.99	20.17	65.90	20.46	65.81	20.75	65.72	21.04	69
70	66.94	20.47	66.85	20.76	66.76	21.05	66.67	21.34	70
71	67.90	20.76	67.81	21.05	67.71	21.35	67.62	21.65	71
72	68.85	21.05	68.76	21.35	68.67	21.65	68.57	21.95	72
73	69.81	21.34	69.72	21.65	69.62	21.95	69.52	22.26	73
74	70.77	21.64	70.67	21.94	70.58	22.25	70.48	22.56	74
75	71.72	21.93	71.63	22.24	71.53	22.55	71.43	22.86	75
76	72.68	22.22	72.58	22.54	72.48	22.85	72.38	23.17	76
77	73.64	22.51	73.54	22.83	73.44	23.15	73.33	23.47	77
78	74.59	22.80	74.49	23.13	74.39	23.46	74.29	23.78	78
79	75.55	23.10	75.45	23.43	75.34	23.76	75.24	24.08	79
80	76.50	23.39	76.40	23.72	76.30	24.06	76.19	24.39	80
81	77.46	23.68	77.36	24.02	77.25	24.36	77.14	24.69	81
82	78.42	23.97	78.81	24.32	78.20	24.66	78.10	25.00	82
83	79.37	24.27	79.27	24.61	79.16	25.96	79.05	25.30	83
84	80.33	24.56	80.22	24.91	80.11	25.26	80.00	25.61	84
85	81.29	24.85	81.18	25.21	81.07	25.56	80.95	25.91	85
86	82.24	25.14	82.13	25.50	82.02	25.86	81.91	26.22	86
87	83.20	25.44	83.09	25.80	82.97	26.16	82.86	26.52	87
88	84.15	25.73	84.04	26.10	83.93	26.46	83.81	26.83	88
89	85.11	26.02	85.00	26.39	84.88	26.76	84.76	27.13	89
90	86.07	26.31	85.95	26.69	85.83	27.06	85.72	27.44	90
91	87.02	26.61	86.91	26.99	86.79	27.36	86.67	27.74	91
92	87.98	26.90	87.86	27.28	87.74	27.66	87.62	28.05	92
93	88.94	27.19	88.82	27.58	88.70	27.97	88.57	28.35	93
94	89.89	27.48	89.77	27.87	89.65	28.27	89.53	28.66	94
95	90.85	27.78	90.73	28.17	90.60	28.57	90.48	28.96	95
96	91.81	28.07	91.68	28.47	91.56	28.87	91.43	29.27	96
97	92.76	28.36	92.64	28.76	92.51	29.17	92.38	29.57	97
98	93.72	28.65	93.59	29.06	93.46	29.47	93.33	29.88	98
99	94.67	28.94	94.55	29.36	94.42	29.77	94.29	30.18	99
100	95.63	29.24	95.50	29.65	95.37	30.07	95.24	30.49	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	73 Deg.		72¾ Deg.		72½ Deg.		72¼ Deg.		

Distance.	18 Deg.		18¼ Deg.		18½ Deg.		18¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.95	0.31	0.95	0.31	0.95	0.32	0.95	0.32	1
2	1.90	0.62	1.90	0.63	1.90	0.63	1.89	0.64	2
3	2.85	0.93	2.85	0.94	2.84	0.95	2.84	0.96	3
4	3.80	1.24	3.80	1.25	3.79	1.27	3.79	1.29	4
5	4.76	1.55	4.75	1.57	4.74	1.59	4.73	1.61	5
6	5.71	1.85	5.70	1.88	5.69	1.90	5.68	1.93	6
7	6.66	2.16	6.65	2.19	6.64	2.22	6.63	2.25	7
8	7.61	2.47	7.60	2.51	7.59	2.54	7.58	2.57	8
9	8.56	2.78	8.55	2.82	8.53	2.86	8.52	2.89	9
10	9.51	3.09	9.50	3.13	9.48	3.17	9.47	3.21	10
11	10.46	3.40	10.45	3.44	10.43	3.49	10.42	3.54	11
12	11.41	3.71	11.40	3.76	11.38	3.81	11.36	3.86	12
13	12.36	4.02	12.35	4.07	12.33	4.12	12.31	4.18	13
14	13.31	4.33	13.30	4.38	13.28	4.44	13.26	4.50	14
15	14.27	4.64	14.25	4.70	14.22	4.76	14.20	4.82	15
16	15.22	4.94	15.20	5.01	15.17	5.08	15.15	5.14	16
17	16.17	5.25	16.14	5.32	16.12	5.39	16.10	5.46	17
18	17.12	5.56	17.09	5.64	17.07	5.71	17.04	5.79	18
19	18.07	5.87	18.04	5.95	18.02	6.03	17.99	6.11	19
20	19.02	6.18	18.99	6.26	18.97	6.35	18.94	6.43	20
21	19.97	6.49	19.94	6.58	19.91	6.66	19.89	6.75	21
22	20.92	6.80	20.89	6.89	20.86	6.98	20.83	7.07	22
23	21.87	7.11	21.84	7.20	21.81	7.30	21.78	7.39	23
24	22.83	7.42	22.79	7.52	22.76	7.62	22.73	7.71	24
25	23.78	7.73	23.74	7.83	23.71	7.93	23.67	8.04	25
26	24.73	8.03	24.69	8.14	24.66	8.25	24.62	8.36	26
27	25.68	8.34	25.64	8.46	25.60	8.57	25.57	8.68	27
28	26.63	8.65	26.59	8.77	26.55	8.88	26.51	9.00	28
29	27.58	8.96	27.54	9.08	27.50	9.20	27.46	9.32	29
30	28.53	9.27	28.49	9.39	28.45	9.52	28.41	9.64	30
31	29.48	9.58	29.44	9.71	29.40	9.84	29.35	9.96	31
32	30.43	9.89	30.39	10.02	30.35	10.15	30.30	10.29	32
33	31.38	10.20	31.34	10.33	31.29	10.47	31.25	10.61	33
34	32.34	10.51	32.29	10.65	32.24	10.79	32.20	10.93	34
35	33.29	10.82	33.24	10.96	33.19	11.11	33.14	11.25	35
36	34.24	11.12	34.19	11.27	34.14	11.42	34.09	11.57	36
37	35.19	11.43	35.14	11.59	35.09	11.74	35.04	11.89	37
38	36.14	11.74	36.09	11.90	36.04	12.06	35.98	12.21	38
39	37.09	12.05	37.04	12.21	36.98	12.37	36.93	12.54	39
40	38.04	12.36	37.99	12.53	37.93	12.69	37.88	12.86	40
41	38.99	12.67	38.94	12.84	38.88	13.01	38.82	13.18	41
42	39.94	12.98	39.89	13.15	39.83	13.33	39.77	13.50	42
43	40.90	13.29	40.84	13.47	40.78	13.64	40.72	13.82	43
44	41.85	13.60	41.79	13.78	41.73	13.96	41.66	14.14	44
45	42.80	13.91	42.74	14.09	42.67	14.28	42.61	14.46	45
46	43.75	14.21	43.69	14.41	43.62	14.60	43.56	14.79	46
47	44.70	14.52	44.64	14.72	44.57	14.91	44.51	15.11	47
48	45.65	14.83	45.59	15.03	45.52	15.23	45.45	15.43	48
49	46.60	15.14	46.54	15.35	46.47	15.55	46.40	15.75	49
50	47.55	15.45	47.48	15.66	47.42	15.87	47.35	16.07	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	72 Deg.		71¾ Deg.		71½ Deg.		71¼ Deg.		

Distance.	18 Deg.		18¼ Deg.		18½ Deg.		18¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	48.50	15.76	48.43	15.97	48.36	16.18	48.29	16.39	51
52	49.45	16.07	49.38	16.28	49.31	16.50	49.24	16.71	52
53	50.41	16.38	50.33	16.60	50.26	16.82	50.19	17.04	53
54	51.36	16.69	51.28	16.91	51.21	17.13	51.13	17.36	54
55	52.31	17.00	52.23	17.22	52.16	17.45	52.08	17.68	55
56	53.26	17.30	53.18	17.54	53.11	17.77	53.03	18.00	56
57	54.21	17.61	54.13	17.85	54.05	18.09	53.98	18.32	57
58	55.16	17.92	55.08	18.16	55.00	18.40	54.92	18.64	58
59	56.11	18.23	56.03	18.48	55.95	18.72	55.87	18.96	59
60	57.06	18.54	56.98	18.79	56.90	19.04	56.82	19.29	60
61	58.01	18.85	57.93	19.10	57.85	19.36	57.76	19.61	61
62	58.97	19.16	58.88	19.42	58.80	19.67	58.71	19.93	62
63	59.92	19.47	59.83	19.73	59.74	19.99	59.66	20.25	63
64	60.87	19.78	60.78	20.04	60.69	20.31	60.60	20.57	64
65	61.82	20.09	61.73	20.36	61.64	20.62	61.55	20.89	65
66	62.77	20.40	62.68	20.67	62.59	20.94	62.50	21.22	66
67	63.72	20.70	63.63	20.98	63.54	21.26	63.44	21.54	67
68	64.67	21.01	64.58	21.30	64.49	21.58	64.39	21.86	68
69	65.62	21.32	65.53	21.61	65.43	21.89	65.34	22.18	69
70	66.57	21.63	66.48	21.92	66.38	22.21	66.29	22.50	70
71	67.53	21.94	67.43	22.23	67.33	22.53	67.23	22.82	71
72	68.48	22.25	68.38	22.55	68.28	22.85	68.18	23.14	72
73	69.43	22.56	69.33	22.86	69.23	23.16	69.13	23.47	73
74	70.38	22.87	70.28	23.17	70.18	23.48	70.07	23.79	74
75	71.33	23.18	71.23	23.49	71.12	23.80	71.02	24.11	75
76	72.28	23.49	72.18	23.80	72.07	24.12	71.97	24.43	76
77	73.23	23.79	73.13	24.11	73.02	24.43	72.91	24.75	77
78	74.18	24.10	74.08	24.43	73.97	24.75	73.86	25.07	78
79	75.13	24.41	75.03	24.74	74.92	25.07	74.81	25.39	79
80	76.08	24.72	75.98	25.05	75.87	25.38	75.75	25.72	80
81	77.04	25.03	76.93	25.37	76.81	25.70	76.70	26.04	81
82	77.99	25.34	77.88	25.68	77.76	26.02	77.65	26.36	82
83	78.94	25.65	78.83	25.99	78.71	26.34	78.60	26.68	83
84	79.89	25.96	79.77	26.31	79.66	26.65	79.54	27.00	84
85	80.84	26.27	80.72	26.62	80.61	26.97	80.49	27.32	85
86	81.79	26.58	81.67	26.93	81.56	27.29	81.44	27.64	86
87	82.74	26.88	82.62	27.25	82.50	27.61	82.38	27.97	87
88	83.69	27.19	83.57	27.56	83.45	27.92	83.33	28.29	88
89	84.64	27.50	84.52	27.87	84.40	28.24	84.28	28.61	89
90	85.60	27.81	85.47	28.18	85.35	28.56	85.22	28.93	90
91	86.55	28.12	86.42	28.50	86.30	28.87	86.17	29.25	91
92	87.50	28.43	87.37	28.81	87.25	29.19	87.12	29.57	92
93	88.45	28.74	88.32	29.12	88.19	29.51	88.06	29.89	93
94	89.40	29.05	89.27	29.44	89.14	29.83	89.01	30.22	94
95	90.35	29.36	90.22	29.75	90.09	30.14	89.96	30.54	95
96	91.30	29.67	91.17	30.06	91.04	30.46	90.91	30.86	96
97	92.25	29.97	92.12	30.38	91.99	30.78	91.85	31.18	97
98	93.20	30.28	93.07	30.69	92.94	31.10	92.80	31.50	98
99	94.15	30.59	94.02	31.00	93.88	31.41	93.75	31.82	99
100	95.11	30.90	94.97	31.32	94.83	31.73	94.69	32.14	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	72 Deg.		71¾ Deg.		71½ Deg.		71¼ Deg.		

Distance.	19 Deg.		19¼ Deg.		19½ Deg.		19¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.95	0.33	0.94	0.33	0.94	0.33	0.94	0.34	1
2	1.89	0.65	1.89	0.66	1.89	0.67	1.88	0.68	2
3	2.84	0.98	2.83	0.99	2.83	1.00	2.82	1.01	3
4	3.78	1.30	3.78	1.32	3.77	1.34	3.76	1.35	4
5	4.73	1.63	4.72	1.65	4.71	1.67	4.71	1.69	5
6	5.67	1.95	5.66	1.98	5.66	2.00	5.65	2.03	6
7	6.62	2.28	6.61	2.31	6.60	2.34	6.59	2.37	7
8	7.56	2.60	7.55	2.64	7.54	2.67	7.53	2.70	8
9	8.51	2.93	8.50	2.97	8.48	3.00	8.47	3.04	9
10	9.46	3.26	9.44	3.30	9.43	3.34	9.41	3.38	10
11	10.40	3.58	10.38	3.63	10.37	3.67	10.35	3.72	11
12	11.35	3.91	11.33	3.96	11.31	4.01	11.29	4.06	12
13	12.29	4.23	12.27	4.29	12.25	4.34	12.24	4.39	13
14	13.24	4.56	13.22	4.62	13.20	4.67	13.18	4.73	14
15	14.18	4.88	14.16	4.95	14.14	5.01	14.12	5.07	15
16	15.13	5.21	15.11	5.28	15.08	5.34	15.06	5.41	16
17	16.07	5.53	16.05	5.60	16.02	5.67	16.00	5.74	17
18	17.02	5.86	16.99	5.93	16.97	6.01	16.94	6.08	18
19	17.96	6.19	17.94	6.26	17.91	6.34	17.88	6.42	19
20	18.91	6.51	18.88	6.59	18.85	6.68	18.82	6.76	20
21	19.86	6.84	19.83	6.92	19.80	7.01	19.76	7.10	21
22	20.80	7.16	20.77	7.25	20.74	7.34	20.71	7.43	22
23	21.75	7.49	21.71	7.58	21.68	7.68	21.65	7.77	23
24	22.69	7.81	22.66	7.91	22.62	8.01	22.59	8.11	24
25	23.64	8.14	23.60	8.24	23.57	8.35	23.53	8.45	25
26	24.58	8.46	24.55	8.57	24.51	8.68	24.47	8.79	26
27	25.53	8.79	25.49	8.90	25.45	9.01	25.41	9.12	27
28	26.47	9.12	26.43	9.23	26.39	9.35	26.35	9.46	28
29	27.42	9.44	27.38	9.56	27.34	9.68	27.29	9.80	29
30	28.37	9.77	28.32	9.89	28.28	10.01	28.24	10.14	30
31	29.31	10.09	29.27	10.22	29.22	10.35	29.18	10.48	31
32	30.26	10.42	30.21	10.55	30.16	10.68	30.12	10.81	32
33	31.20	10.74	31.15	10.88	31.11	11.02	31.06	11.15	33
34	32.15	11.07	32.10	11.21	32.05	11.35	32.00	11.49	34
35	33.09	11.39	33.04	11.54	32.99	11.68	32.94	11.83	35
36	34.04	11.72	33.99	11.87	33.94	12.02	33.88	12.17	36
37	34.98	12.05	34.93	12.20	34.88	12.35	34.82	12.50	37
38	35.93	12.37	35.88	12.53	35.82	12.68	35.76	12.84	38
39	36.88	12.70	36.82	12.86	36.76	13.02	36.71	13.18	39
40	37.82	13.02	37.76	13.19	37.71	13.35	37.65	13.52	40
41	38.77	13.35	38.71	13.52	38.65	13.69	38.59	13.85	41
42	39.71	13.67	39.65	13.85	39.59	14.02	39.53	14.19	42
43	40.66	14.00	40.60	14.18	40.53	14.35	40.47	14.53	43
44	41.60	14.32	41.54	14.51	41.48	14.69	41.41	14.87	44
45	42.55	14.65	42.48	14.84	42.42	15.02	42.35	15.21	45
46	43.49	14.98	43.43	15.17	43.36	15.36	43.29	15.54	46
47	44.44	15.30	44.37	15.50	44.30	15.69	44.24	15.88	47
48	45.38	15.63	45.32	15.83	45.25	16.02	45.18	16.22	48
49	46.33	15.95	46.26	16.15	46.19	16.36	46.12	16.56	49
50	47.28	16.28	47.20	16.48	47.13	16.69	47.06	16.90	50
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance.	71 Deg.		70¾ Deg.		70½ Deg.		70¼ Deg.		Distance.

Distance.	19 Deg.		19¼ Deg.		19½ Deg.		19¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	48.22	16.60	48.15	16.81	48.07	17.02	48.00	17.23	51
52	49.17	16.93	49.09	17.14	49.02	17.36	48.94	17.57	52
53	50.11	17.26	50.04	17.47	49.96	17.69	49.88	17.91	53
54	51.06	17.58	50.98	17.80	50.90	18.03	50.82	18.25	54
55	52.00	17.91	51.92	18.13	51.85	18.36	51.76	18.59	55
56	52.95	18.23	52.87	18.46	52.79	18.69	52.71	18.92	56
57	53.89	18.56	53.81	18.79	53.73	19.03	53.65	19.26	57
58	54.84	18.88	54.76	19.12	54.67	19.36	54.59	19.60	58
59	55.79	19.21	55.70	19.45	55.62	19.69	55.53	19.94	59
60	56.73	19.53	56.65	19.78	56.56	20.03	56.47	20.27	60
61	57.68	19.86	57.59	20.11	57.50	20.36	57.41	20.61	61
62	58.62	20.19	58.53	20.44	58.44	20.70	58.35	20.95	62
63	59.57	20.51	59.48	20.77	59.39	21.03	59.29	21.29	63
64	60.51	20.84	60.42	21.10	60.33	21.36	60.24	21.63	64
65	61.46	21.16	61.37	21.43	61.27	21.70	61.18	21.96	65
66	62.40	21.49	62.31	21.76	62.21	22.03	62.12	22.30	66
67	63.35	21.81	63.25	22.09	63.16	22.37	63.06	22.64	67
68	64.30	22.14	64.20	22.42	64.10	22.70	64.00	22.98	68
69	65.24	22.46	65.14	22.75	65.04	23.03	64.94	23.32	69
70	66.19	22.79	66.09	23.08	65.98	23.37	65.88	23.65	70
71	67.13	23.12	67.03	23.41	66.93	23.70	66.82	23.99	71
72	68.08	23.44	67.97	23.74	67.87	24.03	67.76	24.33	72
73	69.02	23.77	68.92	24.07	68.81	24.37	68.71	24.67	73
74	69.97	24.09	69.86	24.40	69.76	24.70	69.65	25.01	74
75	70.91	24.42	70.81	24.73	70.70	25.04	70.59	25.34	75
76	71.86	24.74	71.75	25.06	71.64	25.37	71.53	25.68	76
77	72.80	25.07	72.69	25.39	72.58	25.70	72.47	26.02	77
78	73.75	25.39	73.64	25.72	73.53	26.04	73.41	26.36	78
79	74.70	25.72	74.58	26.05	74.47	26.37	74.35	26.70	79
80	75.64	26.05	75.53	26.38	75.41	26.70	75.29	27.03	80
81	76.59	26.37	76.47	26.70	76.35	27.04	76.24	27.37	81
82	77.53	26.70	77.42	27.03	77.30	27.37	77.18	27.71	82
83	78.48	27.02	78.36	27.36	78.24	27.71	78.12	28.05	83
84	79.42	27.35	79.30	27.69	79.18	28.04	79.06	28.39	84
85	80.37	27.67	80.25	28.02	80.12	28.37	80.00	28.72	85
86	81.31	28.00	81.19	28.35	81.07	28.71	80.94	29.06	86
87	82.26	28.32	82.14	28.68	82.01	29.04	81.88	29.40	87
88	83.21	28.65	83.08	29.01	92.95	29.37	82.82	29.74	88
89	84.15	28.98	84.02	29.34	83.90	29.71	83.76	30.07	89
90	85.10	29.30	84.97	29.67	84.84	30.04	84.71	30.41	90
91	86.04	29.63	85.91	30.00	85.78	30.38	85.65	30.75	91
92	86.99	29.95	86.86	30.33	86.72	30.71	86.59	31.09	92
93	87.93	30.28	87.80	30.66	87.67	31.04	87.53	31.43	93
94	88.88	30.60	88.74	30.99	88.61	31.38	88.47	31.76	94
95	89.82	30.93	89.69	31.32	89.55	31.71	89.41	32.10	95
96	90.77	31.25	90.63	31.65	90.49	32.05	90.35	32.44	96
97	91.72	31.58	91.58	31.98	91.44	32.38	91.29	32.78	97
98	92.66	31.91	92.52	32.31	92.38	32.71	92.24	33.12	98
99	93.61	32.23	93.46	32.64	93.32	33.05	93.18	33.45	99
100	94.55	32.56	94.41	32.97	94.26	33.38	94.12	33.79	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	71 Deg.		70¾ Deg.		70½ Deg.		70¼ Deg.		

Distance.	20 Deg.		20¼ Deg.		20½ Deg.		20¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.94	0.34	0.94	0.35	0.94	0.35	0.94	0.35	1
2	1.88	0.68	1.88	0.69	1.87	0.70	1.87	0.71	2
3	2.82	1.03	2.81	1.04	2.81	1.05	2.81	1.06	3
4	3.76	1.37	3.75	1.38	3.75	1.40	3.74	1.42	4
5	4.70	1.71	4.69	1.73	4.68	1.75	4.68	1.77	5
6	5.64	2.05	5.63	2.08	5.62	2.10	5.61	2.13	6
7	6.58	2.39	6.57	2.42	6.56	2.45	6.55	2.48	7
8	7.52	2.74	7.51	2.77	7.49	2.80	7.48	2.83	8
9	8.46	3.08	8.44	3.12	8.43	3.15	8.42	3.19	9
10	9.40	3.42	9.38	3.46	9.37	3.50	9.35	3.54	10
11	10.34	3.76	10.32	3.81	10.30	3.85	10.29	3.90	11
12	11.28	4.10	11.26	4.15	11.24	4.20	11.22	4.25	12
13	12.22	4.45	12.20	4.50	12.18	4.55	12.16	4.61	13
14	13.16	4.79	13.13	4.85	13.11	4.90	13.09	4.96	14
15	14.10	5.13	14.07	5.19	14.05	5.25	14.03	5.31	15
16	15.04	5.47	15.01	5.54	14.99	5.60	14.96	5.67	16
17	15.97	5.81	15.95	5.88	15.92	5.95	15.90	6.02	17
18	16.91	6.16	16.89	6.23	16.86	6.30	16.83	6.38	18
19	17.85	6.50	17.83	6.58	17.80	6.65	17.77	6.73	19
20	18.79	6.84	18.76	6.92	18.73	7.00	18.70	7.09	20
21	19.73	7.18	19.70	7.27	19.67	7.35	19.64	7.44	21
22	20.67	7.52	20.64	7.61	20.61	7.70	20.57	7.79	22
23	21.61	7.87	21.58	7.96	21.54	8.05	21.51	8.15	23
24	22.55	8.21	22.52	8.31	22.48	8.40	22.44	8.50	24
25	23.49	8.55	23.45	8.65	23.42	8.76	23.38	8.86	25
26	24.43	8.89	24.39	9.00	24.35	9.11	24.31	9.21	26
27	25.37	9.23	25.33	9.35	25.29	9.46	25.25	9.57	27
28	26.31	9.58	26.27	9.69	26.23	9.81	26.18	9.92	28
29	27.25	9.92	27.21	10.04	27.16	10.16	27.12	10.27	29
30	28.19	10.26	28.15	10.38	28.10	10.51	28.05	10.63	30
31	29.13	10.60	29.08	10.73	29.04	10.86	28.99	10.98	31
32	30.07	10.94	30.02	11.08	29.97	11.21	29.92	11.34	32
33	31.01	11.29	30.96	11.42	30.91	11.56	30.86	11.69	33
34	31.95	11.63	31.90	11.77	31.85	11.91	31.79	12.05	34
35	32.89	11.97	32.84	12.11	32.78	12.26	32.73	12.40	35
36	33.83	12.31	33.77	12.46	33.72	12.61	33.66	12.75	36
37	34.77	12.65	34.71	12.81	34.66	12.96	34.60	13.11	37
38	35.71	13.00	35.65	13.15	35.59	13.31	35.54	13.46	38
39	36.65	13.34	36.59	13.50	36.53	13.66	36.47	13.82	39
40	37.59	13.68	37.53	13.84	37.47	14.01	37.41	14.17	40
41	38.53	14.02	38.47	14.19	38.40	14.36	38.34	14.53	41
42	39.47	14.36	39.40	14.54	39.34	14.71	39.28	14.88	42
43	40.41	14.71	40.34	14.88	40.28	15.06	40.21	15.23	43
44	41.35	15.05	41.28	15.23	41.21	15.41	41.15	15.59	44
45	42.29	15.39	42.22	15.58	42.15	15.76	42.08	15.94	45
46	43.23	15.73	43.16	15.92	43.09	16.11	43.02	16.30	46
47	44.17	16.07	44.09	16.27	44.02	16.46	43.95	16.65	47
48	45.11	16.42	45.03	16.61	44.96	16.81	44.89	17.01	48
49	46.04	16.76	45.97	16.96	45.90	17.16	45.82	17.36	49
50	46.98	17.10	46.91	17.31	46.83	17.51	46.76	17.71	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	70 Deg.		69¾ Deg.		69½ Deg.		69¼ Deg.		

Distance.	20 Deg.		20¼ Deg.		20½ Deg.		20¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	47.92	17.44	47.85	17.65	47.77	17.86	47.69	18.07	51
52	48.86	17.79	48.79	18.00	48.71	18.21	48.63	18.42	52
53	49.80	18.13	49.72	18.34	49.64	18.56	49.56	18.78	53
54	50.74	18.47	50.66	18.69	50.58	18.91	50.50	19.13	54
55	51.68	18.81	51.60	19.04	51.52	19.26	51.43	19.49	55
56	52.62	19.15	52.54	19.38	52.45	19.61	52.37	19.84	56
57	53.56	19.50	53.48	19.73	53.39	19.96	53.30	20.19	57
58	54.50	19.84	54.42	20.07	54.33	20.31	54.24	20.55	58
59	55.44	20.18	55.35	20.42	55.26	20.66	55.17	20.90	59
60	56.38	20.52	56.29	20.77	56.20	21.01	56.11	21.26	60
61	57.32	20.86	57.23	21.11	57.14	21.36	57.04	21.61	61
62	58.26	21.21	58.17	21.46	58.07	21.71	57.98	21.97	62
63	59.20	21.55	59.11	21.81	59.01	22.06	58.91	22.32	63
64	60.14	21.89	60.04	22.15	59.95	22.41	59.85	22.67	64
65	61.08	22.23	60.98	22.50	60.88	22.76	60.78	23.03	65
66	62.02	22.57	61.92	22.84	61.82	23.11	61.72	23.38	66
67	62.96	22.92	62.86	23.19	62.76	23.46	62.65	23.74	67
68	63.90	23.26	63.80	23.54	63.69	23.81	63.59	24.09	68
69	64.84	23.60	64.74	23.88	64.63	24.16	64.52	24.45	69
70	65.78	23.94	65.67	24.23	65.57	24.51	65.46	24.80	70
71	66.72	24.28	66.61	24.57	66.50	24.86	66.39	25.15	71
72	67.66	24.63	67.55	24.92	67.44	25.21	67.33	25.51	72
73	68.60	24.97	68.49	25.27	68.38	25.57	68.26	25.86	73
74	69.54	25.31	69.43	25.61	69.31	25.92	69.20	26.22	74
75	70.48	25.65	70.36	25.96	70.25	26.27	70.14	26.57	75
76	71.42	25.99	71.30	26.30	71.19	26.62	71.07	26.93	76
77	72.36	26.34	72.24	26.65	72.12	26.97	72.01	27.28	77
78	73.30	26.68	73.18	27.00	73.06	27.32	72.94	27.63	78
79	74.24	27.02	74.12	27.34	74.00	27.67	73.88	27.99	79
80	75.18	27.36	75.06	27.69	74.93	28.02	74.81	28.34	80
81	76.12	27.70	75.99	28.04	75.87	28.37	75.75	28.70	81
82	77.05	28.05	76.93	28.38	76.81	28.72	76.68	29.05	82
83	77.99	28.39	77.87	28.73	77.74	29.07	77.62	29.41	83
84	78.93	28.73	78.81	29.07	78.68	29.42	78.55	29.76	84
85	79.87	29.07	79.75	29.42	79.62	29.77	79.49	30.11	85
86	80.81	29.41	80.68	29.77	80.55	30.12	80.42	30.47	86
87	81.75	29.76	81.62	30.11	81.49	30.47	81.36	30.82	87
88	82.69	30.10	82.56	30.46	82.43	30.82	82.29	31.18	88
89	83.63	30.44	83.50	30.80	83.36	31.17	83.23	31.53	89
90	84.57	30.78	84.44	31.15	84.30	31.52	84.16	31.89	90
91	85.51	31.12	85.38	31.50	85.24	31.87	85.10	32.24	91
92	86.45	31.47	86.31	31.84	86.17	32.22	86.03	32.59	92
93	87.39	31.81	87.25	32.19	87.11	32.57	86.97	32.95	93
94	88.33	32.15	88.19	32.54	88.05	32.92	87.90	33.30	94
95	89.27	32.49	89.13	32.88	88.98	33.27	88.84	33.66	95
96	90.21	32.83	90.07	33.23	89.92	33.62	89.77	34.01	96
97	91.15	33.18	91.00	33.57	90.86	33.97	90.71	34.37	97
98	92.09	33.52	91.94	33.92	91.79	34.32	91.64	34.72	98
99	93.03	33.86	92.88	34.27	92.73	34.67	92.58	35.07	99
100	93.97	34.20	93.82	34.61	93.67	35.02	93.51	35.43	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	70 Deg.		69¾ Deg.		69½ Deg.		69¼ Deg.		

Distance.	21 Deg.		21¼ Deg.		21½ Deg.		21¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.93	0.36	0.93	0.36	0.93	0.37	0.93	0.37	1
2	1.87	0.72	1.86	0.72	1.86	0.73	1.86	0.74	2
3	2.80	1.08	2.80	1.09	2.79	1.10	2.79	1.11	3
4	3.73	1.43	3.73	1.45	3.72	1.47	3.72	1.48	4
5	4.67	1.79	4.66	1.81	4.65	1.83	4.64	1.85	5
6	5.60	2.15	5.59	2.17	5.58	2.20	5.57	2.22	6
7	6.54	2.51	6.52	2.54	6.51	2.57	6.50	2.59	7
8	7.47	2.87	7.46	2.90	7.44	2.93	7.43	2.96	8
9	8.40	3.23	8.39	3.26	8.37	3.30	8.36	3.34	9
10	9.34	3.58	9.32	3.62	9.30	3.67	9.29	3.71	10
11	10.27	3.94	10.25	3.99	10.23	4.03	10.22	4.08	11
12	11.20	4.30	11.18	4.35	11.17	4.40	11.15	4.45	12
13	12.14	4.66	12.12	4.71	12.10	4.76	12.07	4.82	13
14	13.07	5.02	13.05	5.07	13.03	5.13	13.00	5.19	14
15	14.00	5.38	13.98	5.44	13.96	5.50	13.93	5.56	15
16	14.94	5.73	14.91	5.80	14.89	5.86	14.86	5.93	16
17	15.87	6.09	15.84	6.16	15.82	6.23	15.79	6.30	17
18	16.80	6.45	16.78	6.52	16.75	6.60	16.72	6.67	18
19	17.74	6.81	17.71	6.89	17.68	6.96	17.65	7.04	19
20	18.67	7.17	18.64	7.25	18.61	7.33	18.58	7.41	20
21	19.61	7.53	19.57	7.61	19.54	7.70	19.50	7.78	21
22	20.54	7.88	20.50	7.97	20.47	8.06	20.43	8.15	22
23	21.47	8.24	21.44	8.34	21.40	8.43	21.36	8.52	23
24	22.41	8.60	22.37	8.70	22.33	8.80	22.29	8.89	24
25	23.34	8.96	23.30	9.06	23.26	9.16	23.22	9.26	25
26	24.27	9.32	24.23	9.42	24.19	9.53	24.15	9.63	26
27	25.21	9.68	25.16	9.79	25.12	9.90	25.08	10.01	27
28	26.14	10.03	26.10	10.15	26.05	10.26	26.01	10.38	28
29	27.07	10.39	27.03	10.51	26.98	10.63	26.94	10.75	29
30	28.01	10.75	27.96	10.87	27.91	11.00	27.86	11.12	30
31	28.94	11.11	28.89	11.24	28.84	11.36	28.79	11.49	31
32	29.87	11.47	29.82	11.60	29.77	11.73	29.72	11.86	32
33	30.81	11.83	30.76	11.96	30.70	12.09	30.65	12.23	33
34	31.74	12.18	31.69	12.32	31.63	12.46	31.58	12.60	34
35	32.68	12.54	32.62	12.69	32.56	12.83	32.51	12.97	35
36	33.61	12.90	33.55	13.05	33.50	13.19	33.44	13.34	36
37	34.54	13.26	34.48	13.41	34.43	13.56	34.37	13.71	37
38	35.48	13.62	35.42	13.77	35.36	13.93	35.29	14.08	38
39	36.41	13.98	36.35	14.14	36.29	14.29	36.22	14.45	39
40	37.34	14.33	37.28	14.50	37.22	14.66	37.15	14.82	40
41	38.28	14.69	38.21	14.86	38.15	15.03	38.08	15.19	41
42	39.21	15.05	39.14	15.22	39.08	15.39	39.01	15.56	42
43	40.14	15.41	40.08	15.58	40.01	15.76	39.94	15.93	43
44	41.08	15.77	41.01	15.95	40.94	16.13	40.87	16.30	44
45	42.01	16.13	41.94	16.31	41.87	16.49	41.80	16.68	45
46	42.94	16.48	42.87	16.67	42.80	16.86	42.73	17.05	46
47	43.88	16.84	43.80	17.03	43.73	17.23	43.65	17.42	47
48	44.81	17.20	44.74	17.40	44.66	17.59	44.58	17.79	48
49	45.75	17.56	45.67	17.76	45.59	17.96	45.51	18.16	49
50	46.68	17.92	46.60	18.12	46.52	18.33	46.44	18.53	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	69 Deg.		68¾ Deg.		68½ Deg.		68¼ Deg.		

Distance.	21 Deg.		21¼ Deg.		21½ Deg.		21¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	47.61	18.28	47.53	18.48	47.45	18.69	47.37	18.90	51
52	48.55	18.64	48.46	18.85	48.38	19.06	48.30	19.27	52
53	49.48	18.99	49.40	19.21	49.31	19.42	49.23	19.64	53
54	50.41	19.35	50.33	19.57	50.24	19.79	50.16	20.01	54
55	51.35	19.71	51.26	19.93	51.17	20.16	51.08	20.38	55
56	52.28	20.07	52.19	20.30	52.10	20.52	52.01	20.75	56
57	53.21	20.43	53.12	20.66	53.03	20.89	52.94	21.12	57
58	54.15	20.79	54.06	21.02	53.96	21.26	53.87	21.49	58
59	55.08	21.14	54.99	21.38	54.89	21.62	54.80	21.86	59
60	56.01	21.50	55.92	21.75	55.83	21.99	55.73	22.23	60
61	56.95	21.86	56.85	22.11	56.76	22.36	56.66	22.60	61
62	57.88	22.22	57.78	22.47	57.69	22.72	57.59	22.97	62
63	58.82	22.58	58.72	22.83	58.62	23.09	58.52	23.35	63
64	59.75	22.94	59.65	23.20	59.55	23.46	59.44	23.72	64
65	60.68	23.29	60.58	23.56	60.48	23.82	60.37	24.09	65
66	61.62	23.65	61.51	23.92	61.41	24.19	61.30	24.46	66
67	62.55	24.01	62.44	24.28	62.34	24.56	62.23	24.83	67
68	63.48	24.37	63.38	24.65	63.27	24.92	63.16	25.20	68
69	64.42	24.73	64.31	25.01	64.20	25.29	64.09	25.57	69
70	65.35	25.09	65.24	25.37	65.13	25.66	65.02	25.94	70
71	66.28	25.44	66.17	25.73	66.06	26.02	65.95	26.31	71
72	67.22	25.80	67.10	26.10	66.99	26.39	66.87	26.68	72
73	68.15	26.16	68.04	26.46	67.92	26.75	67.80	27.05	73
74	69.08	26.52	68.97	26.82	68.85	27.12	68.73	27.42	74
75	70.02	26.88	69.90	27.18	69.78	27.49	69.66	27.79	75
76	70.95	27.24	70.83	27.55	70.71	27.85	70.59	28.16	76
77	71.89	27.59	71.76	27.91	71.64	28.22	71.52	28.53	77
78	72.82	27.95	72.70	28.27	72.57	28.59	72.45	28.90	78
79	73.75	28.31	73.63	28.63	73.50	28.95	73.38	29.27	79
80	74.69	28.67	74.56	29.00	74.43	29.32	74.30	29.64	80
81	75.62	29.03	75.49	29.36	75.36	29.69	75.23	30.02	81
82	76.55	29.39	76.42	29.72	76.29	30.05	76.16	30.39	82
83	77.49	29.74	77.36	30.08	77.22	30.42	77.09	30.76	83
84	78.42	30.10	78.29	30.44	78.16	30.79	78.02	31.13	84
85	79.35	30.46	79.22	30.81	79.09	31.15	78.95	31.50	85
86	80.29	30.82	80.15	31.17	80.02	31.52	79.88	31.87	86
87	81.22	31.18	81.08	31.53	80.95	31.89	80.81	32.24	87
88	82.16	31.54	82.02	31.89	81.88	32.25	81.74	32.61	88
89	83.09	31.89	82.95	32.26	82.81	32.62	82.66	32.98	89
90	84.02	32.25	83.88	32.62	83.74	32.99	83.59	33.35	90
91	84.96	32.61	84.81	32.98	84.67	33.35	84.52	33.72	91
92	85.89	32.97	85.74	33.34	85.60	33.72	85.45	34.09	92
93	86.82	33.33	86.68	33.71	86.53	34.08	86.38	34.46	93
94	87.76	33.69	87.61	34.07	87.46	34.45	87.31	34.83	94
95	88.69	34.04	88.54	34.43	88.39	34.82	88.24	35.20	95
96	89.62	34.40	89.47	34.79	89.32	35.18	89.17	35.57	96
97	90.56	34.76	90.40	35.16	90.25	35.55	90.09	35.94	97
98	91.49	35.12	91.34	35.52	91.18	35.92	91.02	36.31	98
99	92.42	35.48	92.27	35.88	92.11	36.28	91.95	36.69	99
100	93.36	35.84	93.20	36.24	93.04	36.65	92.88	37.06	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	69 Deg.		68¾ Deg.		68½ Deg.		68¼ Deg.		

Distance.	22 Deg.		22¼ Deg.		22½ Deg.		22¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.93	0.37	0.93	0.38	0.92	0.38	0.92	0.39	1
2	1.85	0.75	1.85	0.76	1.85	0.77	1.84	0.77	2
3	2.78	1.12	2.78	1.14	2.77	1.15	2.77	1.16	3
4	3.71	1.50	3.70	1.51	3.70	1.53	3.69	1.55	4
5	4.64	1.87	4.63	1.89	4.62	1.91	4.61	1.93	5
6	5.56	2.25	5.55	2.27	5.54	2.30	5.53	2.32	6
7	6.49	2.62	6.48	2.65	6.47	2.68	6.46	2.71	7
8	7.42	3.00	7.40	3.03	7.39	3.06	7.38	3.09	8
9	8.34	3.37	8.33	3.41	8.31	3.44	8.30	3.48	9
10	9.27	3.75	9.26	3.79	9.24	3.83	9.22	3.87	10
11	10.20	4.12	10.18	4.17	10.16	4.21	10.14	4.25	11
12	11.13	4.50	11.11	4.54	11.09	4.59	11.07	4.64	12
13	12.05	4.87	12.03	4.92	12.01	4.97	11.99	5.03	13
14	12.98	5.24	12.96	5.30	12.93	5.36	12.91	5.41	14
15	13.91	5.62	13.88	5.68	13.86	5.74	13.83	5.80	15
16	14.83	5.99	14.81	6.06	14.78	6.12	14.76	6.19	16
17	15.76	6.37	15.73	6.44	15.71	6.51	15.68	6.57	17
18	16.69	6.74	16.66	6.82	16.63	6.89	16.60	6.96	18
19	17.62	7.12	17.59	7.19	17.55	7.27	17.52	7.35	19
20	18.54	7.49	18.51	7.57	18.48	7.65	18.44	7.73	20
21	19.47	7.87	19.44	7.95	19.40	8.04	19.37	8.12	21
22	20.40	8.24	20.36	8.33	20.33	8.42	20.29	8.51	22
23	21.33	8.62	21.29	8.71	21.25	8.80	21.21	8.89	23
24	22.25	8.99	22.21	9.09	22.17	9.18	22.13	9.28	24
25	23.18	9.37	23.14	9.47	23.10	9.57	23.05	9.67	25
26	24.11	9.74	24.06	9.84	24.02	9.95	23.98	10.05	26
27	25.03	10.11	24.99	10.22	24.94	10.33	24.90	10.44	27
28	25.96	10.49	25.92	10.60	25.87	10.72	25.82	10.83	28
29	26.89	10.86	26.84	10.98	26.79	11.10	26.74	11.21	29
30	27.82	11.24	27.77	11.36	27.72	11.48	27.67	11.60	30
31	28.74	11.61	28.69	11.74	28.64	11.86	28.59	11.99	31
32	29.67	11.99	29.62	12.12	29.56	12.25	29.51	12.37	32
33	30.60	12.36	30.54	12.50	30.49	12.68	30.43	12.76	33
34	31.52	12.74	31.47	12.87	31.41	13.01	31.35	13.15	34
35	32.45	13.11	32.39	13.25	32.34	13.39	32.28	13.53	35
36	33.38	13.49	33.32	13.63	33.26	13.78	33.20	13.92	36
37	34.31	13.86	34.24	14.01	34.18	14.16	34.12	14.31	37
38	35.23	14.24	35.17	14.39	35.11	14.54	35.04	14.70	38
39	36.16	14.61	36.10	14.77	36.03	14.92	35.97	15.08	39
40	37.09	14.98	37.02	15.15	36.96	15.31	36.89	15.47	40
41	38.01	15.36	37.95	15.52	37.88	15.69	37.81	15.86	41
42	38.94	15.73	38.87	15.90	38.80	16.07	38.73	16.24	42
43	39.87	16.11	39.80	16.28	39.73	16.46	39.65	16.63	43
44	40.80	16.48	40.72	16.66	40.65	16.84	40.58	17.02	44
45	41.72	16.86	41.65	17.04	41.57	17.22	41.50	17.40	45
46	42.65	17.23	42.57	17.42	42.50	17.60	42.42	17.79	46
47	43.58	17.61	43.50	17.80	43.42	17.99	43.34	18.18	47
48	44.50	17.98	44.43	18.18	44.35	18.37	44.27	18.56	48
49	45.43	18.36	45.35	18.55	45.27	18.75	45.19	18.95	49
50	46.36	18.73	46.28	18.93	46.19	19.13	46.11	19.34	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	68 Deg.		67¾ Deg.		67½ Deg.		67¼ Deg.		

Distance.	22 Deg.		22¼ Deg.		22½ Deg.		22¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	47.29	19.10	47.20	19.31	47.12	19.52	47.03	19.72	51
52	48.21	19.48	48.13	19.69	48.04	19.90	47.95	20.11	52
53	49.14	19.85	49.05	20.07	48.97	20.28	48.88	20.50	53
54	50.07	20.23	49.98	20.45	49.89	20.66	49.80	20.88	54
55	51.00	20.60	50.90	20.83	50.81	21.05	50.72	21.27	55
56	51.92	20.98	51.83	21.20	51.74	21.43	51.64	21.66	56
57	52.85	21.35	52.76	21.58	52.66	21.81	52.57	22.04	57
58	53.78	21.73	53.68	21.96	53.59	22.20	53.49	22.43	58
59	54.70	22.10	54.61	22.34	54.51	22.58	54.41	22.82	59
60	55.63	22.48	55.53	22.72	55.43	22.96	55.33	23.20	60
61	56.56	22.85	56.47	23.10	56.36	23.34	56.25	23.59	61
62	57.49	23.23	57.38	23.48	57.28	23.73	57.18	23.98	62
63	58.41	23.60	58.31	23.85	58.20	24.11	58.10	24.36	63
64	59.34	23.97	59.23	24.23	59.13	24.49	59.02	24.75	64
65	60.27	24.35	60.16	24.61	60.05	24.87	59.94	25.14	65
66	61.19	24.72	61.09	24.99	60.98	25.26	60.87	25.52	66
67	62.12	25.10	62.01	25.37	61.90	25.64	61.79	25.91	67
68	63.05	25.47	62.94	25.75	62.82	26.02	62.71	26.30	68
69	63.98	25.85	63.86	26.13	63.75	26.41	63.63	26.68	69
70	64.90	26.22	64.79	26.51	64.67	26.79	64.55	27.07	70
71	65.83	26.60	65.71	26.88	65.60	27.17	65.48	27.46	71
72	66.76	26.97	66.64	27.26	66.52	27.55	66.40	27.84	72
73	67.68	27.35	67.56	27.64	67.44	27.94	67.32	28.23	73
74	68.61	27.72	68.49	28.02	68.37	28.32	68.24	28.62	74
75	69.54	28.10	69.42	28.40	69.29	28.70	69.17	29.00	75
76	70.47	28.47	70.34	28.78	70.21	29.08	70.09	29.39	76
77	71.39	28.84	71.27	29.16	71.14	29.47	71.01	29.78	77
78	72.32	29.22	72.19	29.53	72.06	29.85	71.93	30.16	78
79	73.25	29.59	73.12	29.91	72.99	30.23	72.85	30.55	79
80	74.17	29.97	74.04	30.29	73.91	30.61	73.78	30.94	80
81	75.10	30.34	74.97	30.67	74.83	31.00	74.70	31.32	81
82	76.03	30.72	75.89	31.05	75.76	31.38	75.62	31.71	82
83	76.96	31.09	76.82	31.43	76.68	31.76	76.54	32.10	83
84	77.88	31.47	77.75	31.81	77.61	32.15	77.46	32.49	84
85	78.81	31.84	78.67	32.19	78.53	32.53	78.39	32.87	85
86	79.74	32.22	79.60	32.56	79.45	32.91	79.31	33.26	86
87	80.66	32.59	80.52	32.94	80.38	33.29	80.23	33.64	87
88	81.59	32.97	81.45	33.32	81.30	33.68	81.15	34.03	88
89	82.52	33.34	82.37	33.70	82.23	34.06	82.08	34.42	89
90	83.45	33.71	83.30	34.08	83.15	34.44	83.00	34.80	90
91	84.37	34.09	84.22	34.46	84.07	34.82	83.92	35.19	91
92	85.30	34.46	85.15	34.84	85.00	35.21	84.84	35.58	92
93	86.23	34.84	86.08	35.21	85.92	35.59	85.76	35.96	93
94	87.16	35.21	87.00	35.59	86.84	35.97	86.69	36.35	94
95	88.08	35.59	87.93	35.97	87.77	36.35	87.61	36.74	95
96	89.01	35.96	88.85	36.35	88.69	36.74	88.53	37.12	96
97	89.94	36.34	89.78	36.73	89.62	37.12	89.45	37.51	97
98	90.86	36.71	90.70	37.11	90.54	37.50	90.38	37.90	98
99	91.79	37.09	91.63	37.49	91.46	37.89	91.30	38.28	99
100	92.72	37.46	92.55	37.86	92.39	38.27	92.22	38.67	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	68 Deg.		67¾ Deg.		67½ Deg.		67¼ Deg.		

Distance.	23 Deg.		23¼ Deg.		23½ Deg.		23¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.92	0.39	0.92	0.39	0.92	0.40	0.92	0.40	1
2	1.84	0.78	1.84	0.79	1.83	0.80	1.83	0.81	2
3	2.76	1.17	2.76	1.18	2.75	1.20	2.75	1.21	3
4	3.68	1.56	3.68	1.58	3.67	1.59	3.66	1.61	4
5	4.60	1.95	4.59	1.97	4.59	1.99	4.58	2.01	5
6	5.52	2.34	5.51	2.37	5.50	2.39	5.49	2.42	6
7	6.44	2.74	6.43	2.76	6.42	2.79	6.41	2.82	7
8	7.36	3.13	7.35	3.16	7.34	3.19	7.32	3.22	8
9	8.28	3.52	8.27	3.55	8.25	3.59	8.24	3.62	9
10	9.20	3.91	9.19	3.95	9.17	3.99	9.15	4.03	10
11	10.13	4.30	10.11	4.34	10.09	4.39	10.07	4.43	11
12	11.05	4.69	11.03	4.74	11.00	4.78	10.98	4.83	12
13	11.97	5.08	11.94	5.13	11.92	5.18	11.90	5.24	13
14	12.89	5.47	12.86	5.53	12.84	5.58	12.81	5.64	14
15	13.81	5.86	13.78	5.92	13.76	5.98	13.73	6.04	15
16	14.73	6.25	14.70	6.32	14.67	6.38	14.64	6.44	16
17	15.65	6.64	15.62	6.71	15.59	6.78	15.56	6.85	17
18	16.57	7.03	16.54	7.11	16.51	7.18	16.48	7.25	18
19	17.49	7.42	17.46	7.50	17.42	7.58	17.39	7.65	19
20	18.41	7.81	18.38	7.89	18.34	7.97	18.31	8.05	20
21	19.33	8.21	19.29	8.29	19.26	8.37	19.22	8.46	21
22	20.25	8.60	20.21	8.68	20.18	9.77	20.14	8.86	22
23	21.17	8.99	21.13	9.08	21.09	9.17	21.05	9.26	23
24	22.09	9.38	22.05	9.47	22.01	9.57	21.97	9.67	24
25	23.01	9.77	22.97	9.87	22.93	9.97	22.88	10.07	25
26	23.93	10.16	23.89	10.26	23.84	10.37	23.80	10.47	26
27	24.85	10.55	24.81	10.66	24.76	10.77	24.71	10.87	27
28	25.77	10.94	25.7[illegible]	[illegible].05	25.68	11.1[illegible]	25.63	[illegible]	28
29	26.69	11.33	26.64	11.45	[illegible]	11.56	26.54	11.68	29
30	27.62	11.72	27.56	11.84	27.51	11.96	27.46	12.08	30
31	28.54	12.11	28.48	12.24	28.43	12.36	28.37	12.49	31
32	29.46	12.50	29.40	12.63	29.35	12.76	29.29	12.89	32
33	30.38	12.89	30.32	13.08	30.26	13.16	30.21	13.29	33
34	31.30	13.28	31.24	13.42	31.18	13.56	31.12	13.69	34
35	32.22	13.68	32.16	13.82	32.10	13.96	32.04	14.10	35
36	33.14	14.07	33.08	14.21	33.01	14.35	32.95	14.50	36
37	34.06	14.46	34.00	14.61	33.93	14.75	33.87	14.90	37
38	34.98	14.85	34.91	15.00	34.85	15.15	34.78	15.30	38
39	35.90	15.24	35.83	15.39	35.77	15.55	35.70	15.71	39
40	36.82	15.63	36.75	15.79	36.68	15.95	36.61	16.11	40
41	37.74	16.02	37.67	16.18	37.60	16.35	37.53	16.51	41
42	38.66	16.41	38.59	16.58	38.52	16.75	38.44	16.92	42
43	39.58	16.80	39.51	16.97	39.43	17.15	39.36	17.32	43
44	40.50	17.19	40.43	17.37	40.35	17.54	40.27	17.72	44
45	41.42	17.58	41.35	17.76	41.27	17.94	41.19	18.12	45
46	42.34	17.97	42.26	18.16	42.18	18.34	42.10	18.53	46
47	43.26	18.36	43.18	18.55	43.10	18.74	43.02	18.93	47
48	44.18	18.76	44.10	18.95	44.02	19.14	43.93	19.33	48
49	45.10	19.15	45.02	19.34	44.94	19.54	44.85	19.73	49
50	46.03	19.54	45.94	19.74	45.85	19.94	45.77	20.14	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	67 Deg		66¾ Deg.		66½ Deg.		66¼ Deg.		

Distance.	23 Deg. Lat.	23 Deg. Dep.	23¼ Deg. Lat.	23¼ Deg. Dep.	23½ Deg. Lat.	23½ Deg. Dep.	23¾ Deg. Lat.	23¾ Deg. Dep.	Distance.
51	46.95	19.93	46.86	20.13	46.77	20.34	46.68	20.54	51
52	47.87	20.32	47.78	20.53	47.69	20.73	47.60	20.94	52
53	48.79	20.71	48.70	20.92	48.60	21.13	48.51	21.35	53
54	49.71	21.10	49.61	21.32	49.52	21.53	49.43	21.75	54
55	50.63	21.49	50.53	21.71	50.44	21.93	50.34	22.15	55
56	51.55	21.88	51.45	22.11	51.36	22.33	51.26	22.55	56
57	52.47	22.27	52.37	22.50	52.27	22.73	52.17	22.95	57
58	53.39	22.66	53.29	22.90	53.19	23.13	53.09	23.36	58
59	54.31	23.05	54.21	23.29	54.11	23.53	54.00	23.76	59
60	55.23	23.44	55.13	23.68	55.02	23.92	54.92	24.16	60
61	56.15	23.83	56.05	24.08	55.94	24.32	55.83	24.57	61
62	57.07	24.23	56.97	24.47	56.86	24.72	56.75	24.97	62
63	57.99	24.62	57.88	24.87	57.77	25.12	57.66	25.37	63
64	58.91	25.01	58.80	25.26	58.69	25.52	58.58	25.78	64
65	59.83	25.40	59.72	25.66	59.61	25.92	59.50	26.18	65
66	60.75	25.79	60.64	26.05	60.53	26.32	60.41	26.58	66
67	61.67	26.18	61.56	26.45	61.44	26.72	61.33	26.98	67
68	62.59	26.57	62.48	26.84	62.36	27.11	62.24	27.39	68
69	63.51	26.96	63.40	27.24	63.28	27.51	63.16	27.79	69
70	64.44	27.35	64.32	27.63	64.19	27.91	64.07	28.19	70
71	65.36	27.74	65.23	28.03	65.11	28.31	64.99	28.59	71
72	66.28	28.13	66.15	28.42	66.03	28.71	65.90	29.00	72
73	67.20	28.52	67.07	28.82	66.95	29.11	66.82	29.40	73
74	68.12	28.91	67.99	29.21	67.86	29.51	67.73	29.80	74
75	69.04	29.30	68.91	29.61	68.78	29.91	68.65	30.21	75
76	69.96	29.70	69.83	30.00	69.70	30.30	69.56	30.61	76
77	70.88	30.09	70.75	30.40	70.61	30.70	70.48	31.01	77
78	71.80	30.48	71.67	30.79	71.53	31.10	71.39	31.41	78
79	72.72	30.87	72.58	31.18	72.45	31.50	72.31	31.82	79
80	73.64	31.26	73.50	31.58	73.36	31.90	73.22	32.22	80
81	74.56	31.65	74.42	31.97	74.28	32.30	74.14	32.62	81
82	75.48	32.04	75.34	32.37	75.20	32.70	75.06	33.03	82
83	76.40	32.43	76.26	32.76	76.12	33.10	75.97	33.43	83
84	77.32	32.82	77.18	33.16	77.03	33.49	76.89	33.83	84
85	78.24	33.21	78.10	33.55	77.95	33.89	77.80	34.23	85
86	79.16	33.60	79.02	33.95	78.87	34.29	78.72	34.64	86
87	80.08	33.99	79.93	34.34	79.78	34.69	79.63	35.04	87
88	81.00	34.38	80.85	34.74	80.70	35.09	80.55	35.44	88
89	81.92	34.78	81.77	35.13	81.62	35.49	81.46	35.84	89
90	82.85	35.17	82.69	35.53	82.54	35.89	82.38	36.25	90
91	83.77	35.56	83.61	35.92	83.45	36.29	83.29	36.65	91
92	84.69	35.95	84.53	36.32	84.37	36.69	84.21	37.05	92
93	85.61	36.34	85.45	36.71	85.29	37.08	85.12	37.46	93
94	86.53	36.73	86.37	37.11	86.20	37.48	86.04	37.86	94
95	87.45	37.12	87.29	37.50	87.12	37.88	86.95	38.26	95
96	88.37	37.51	88.20	37.90	88.04	38.28	87.87	38.66	96
97	89.29	37.90	89.12	38.29	88.95	38.68	88.79	39.07	97
98	90.21	38.29	90.04	38.68	89.87	39.08	89.70	39.47	98
99	91.13	38.68	90.96	39.08	90.79	39.48	90.62	39.87	99
100	92.05	39.07	91.88	39.47	91.71	39.87	91.53	40.27	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Distance.
	67 Deg.		66¾ Deg.		66½ Deg.		66¼ Deg.		

Distance.	24 Deg.		24¼ Deg.		24½ Deg.		24¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.91	0.41	0.91	0.41	0.91	0.41	0.91	0.42	1
2	1.83	0.81	1.82	0.82	1.82	0.83	1.82	0.84	2
3	2.74	1.22	2.74	1.23	2.73	1.24	2.72	1.26	3
4	3.65	1.63	3.65	1.64	3.64	1.66	3.63	1.67	4
5	4.57	2.03	4.56	2.05	4.55	2.07	4.54	2.09	5
6	5.48	2.44	5.47	2.46	5.46	2.49	5.45	2.51	6
7	6.39	2.85	6.38	2.87	6.37	2.90	6.36	2.93	7
8	7.31	3.25	7.29	3.29	7.28	3.32	7.27	3.35	8
9	8.22	3.66	8.21	3.70	8.19	3.73	8.17	3.77	9
10	9.14	4.07	9.12	4.11	9.10	4.15	9.08	4.19	10
11	10.05	4.47	10.03	4.52	10.01	4.56	9.99	4.61	11
12	10.96	4.88	10.94	4.93	10.92	4.98	10.90	5.02	12
13	11.88	5.29	11.85	5.34	11.83	5.39	11.81	5.44	13
14	12.79	5.69	12.76	5.75	12.74	5.81	12.71	5.86	14
15	13.70	6.10	13.68	6.16	13.65	6.22	13.62	6.28	15
16	14.62	6.51	14.59	6.57	14.56	6.64	14.53	6.70	16
17	15.53	6.92	15.50	6.98	15.47	7.05	15.44	7.12	17
18	16.44	7.32	16.41	7.39	16.38	7.46	16.35	7.54	18
19	17.36	7.73	17.32	7.80	17.29	7.88	17.25	7.95	19
20	18.27	8.13	18.24	8.21	18.20	8.29	18.16	8.37	20
21	19.18	8.54	19.15	8.63	19.11	8.71	19.07	8.79	21
22	20.10	8.95	20.06	9.04	20.02	9.12	19.98	9.21	22
23	21.01	9.35	20.97	9.45	20.93	9.54	20.89	9.63	23
24	21.93	9.76	21.88	9.86	21.84	9.95	21.80	10.05	24
25	22.84	10.17	22.79	10.27	22.75	10.37	22.70	10.47	25
26	23.75	10.58	23.71	10.68	23.66	10.78	23.61	10.89	26
27	24.67	10.98	24.62	11.09	24.57	11.20	24.52	11.30	27
28	25.58	11.39	25.53	11.50	25.48	11.61	25.43	11.72	28
29	26.49	11.80	26.44	11.91	26.39	12.03	26.34	12.14	29
30	27.41	12.20	27.35	12.32	27.30	12.44	27.24	12.56	30
31	28.32	12.61	28.26	12.73	28.21	12.86	28.15	12.98	31
32	29.23	13.02	29.18	13.14	29.12	13.27	29.06	13.40	32
33	30.15	13.42	30.09	13.55	30.03	13.68	29.97	13.82	33
34	31.06	13.83	31.00	13.96	30.94	14.10	30.88	14.23	34
35	31.97	14.24	31.91	14.38	31.85	14.51	31.78	14.65	35
36	32.89	14.64	32.82	14.79	32.76	14.93	32.69	15.07	36
37	33.80	15.05	33.74	15.20	33.67	15.34	33.60	15.49	37
38	34.71	15.46	34.65	15.61	34.58	15.76	34.51	15.91	38
39	35.63	15.86	35.56	16.02	35.49	16.17	35.42	16.33	39
40	36.54	16.27	36.47	16.43	36.40	16.59	36.33	16.75	40
41	37.46	16.68	37.38	16.84	37.31	17.00	37.23	17.16	41
42	38.37	17.08	38.29	17.25	38.22	17.42	38.14	17.58	42
43	39.28	17.49	39.21	17.66	39.13	17.83	39.05	18.00	43
44	40.20	17.90	40.12	18.07	40.04	18.25	39.96	18.42	44
45	41.11	18.30	41.03	18.48	40.95	18.66	40.87	18.84	45
46	42.02	18.71	41.94	18.89	41.86	19.08	41.77	19.26	46
47	42.94	19.12	42.85	19.30	42.77	19.49	42.68	19.68	47
48	43.85	19.52	43.76	19.71	43.68	19.91	43.59	20.10	48
49	44.76	19.93	44.68	20.13	44.59	20.32	44.50	20.51	49
50	45.68	20.34	45.59	20.54	45.50	20.73	45.41	20.93	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	66 Deg.		65¾ Deg.		65½ Deg.		65¼ Deg.		

Distance.	24 Deg.		24¼ Deg.		24½ Deg.		24¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	46.59	20.74	46.50	20.95	46.41	21.15	46.32	21.35	51
52	47.50	21.16	47.41	21.36	47.32	21.56	47.22	21.77	52
53	48.42	21.56	48.32	21.77	48.23	21.98	48.13	22.19	53
54	49.33	21.96	49.24	22.18	49.14	22.39	49.04	22.61	54
55	50.24	22.37	50.15	22.59	50.05	22.81	49.95	23.03	55
56	51.16	22.78	51.06	23.00	50.96	23.22	50.86	23.44	56
57	52.07	23.18	51.97	23.41	51.87	23.64	51.76	23.86	57
58	52.99	23.59	52.88	23.82	52.78	24.05	52.67	24.28	58
59	53.90	24.00	53.79	24.23	53.69	24.47	53.58	24.70	59
60	54.81	24.40	54.71	24.64	54.60	24.88	54.49	25.12	60
61	55.73	24.81	55.62	25.05	55.51	25.30	55.40	25.54	61
62	56.64	25.22	56.53	25.46	56.42	25.71	56.30	25.96	62
63	57.55	25.62	57.44	25.88	57.33	26.13	57.21	26.38	63
64	58.47	26.03	58.35	26.29	58.24	26.54	58.12	26.79	64
65	59.38	26.44	59.26	26.70	59.15	26.96	59.03	27.21	65
66	60.29	26.84	60.18	27.11	60.06	27.37	59.94	27.63	66
67	61.21	27.25	61.09	27.52	60.97	27.78	60.85	28.05	67
68	62.12	27.66	62.00	27.93	61.88	28.20	61.75	28.47	68
69	63.03	28.06	62.91	28.34	62.79	28.61	62.66	28.89	69
70	63.95	28.47	63.82	28.75	63.70	29.03	63.57	29.31	70
71	64.86	28.88	64.74	29.16	64.61	29.44	64.48	29.72	71
72	65.78	29.28	65.65	29.57	65.52	29.86	65.39	30.14	72
73	66.69	29.69	66.56	29.98	66.43	30.27	66.29	30.56	73
74	67.60	30.10	67.47	30.39	67.34	30.69	67.20	30.98	74
75	68.52	30.51	68.38	30.80	68.25	31.10	68.11	31.40	75
76	69.43	30.91	69.29	31.21	69.16	31.52	69.02	31.82	76
77	70.34	31.32	70.21	31.63	70.07	31.93	69.93	32.24	77
78	71.26	31.73	71.12	32.04	70.98	32.35	70.84	32.66	78
79	72.17	32.13	72.03	32.45	71.89	32.76	71.74	33.07	79
80	73.08	32.54	72.94	32.86	72.80	33.18	72.65	33.49	80
81	74.00	32.95	73.85	33.27	73.71	33.59	73.56	33.91	81
82	74.91	33.35	74.76	33.68	74.62	34.00	74.47	34.33	82
83	75.82	33.76	75.68	34.09	75.53	34.42	75.38	34.75	83
84	76.74	34.17	76.59	34.50	76.44	34.83	76.28	35.17	84
85	77.65	34.57	77.50	34.91	77.35	35.25	77.19	35.59	85
86	78.56	34.98	78.41	35.32	78.26	35.66	78.10	36.00	86
87	79.48	35.39	79.32	35.73	79.17	36.08	79.01	36.42	87
88	80.39	35.79	80.24	36.14	80.08	36.49	79.92	36.84	88
89	81.31	36.20	81.15	36.55	80.99	36.91	80.82	37.26	89
90	82.22	36.61	82.06	36.96	81.90	37.32	81.73	37.68	90
91	83.13	37.01	82.97	37.38	82.81	37.74	82.64	38.10	91
92	84.05	37.42	83.88	37.79	83.72	38.15	83.55	38.52	92
93	84.96	37.83	84.79	38.20	84.63	38.57	84.46	38.94	93
94	85.87	38.23	85.71	38.61	85.54	38.98	85.37	39.35	94
95	86.79	38.64	86.62	39.02	86.45	39.40	86.27	39.77	95
96	87.70	39.05	87.53	39.43	87.36	39.81	87.18	40.19	96
97	88.61	39.45	88.44	39.84	88.27	40.23	88.09	40.61	97
98	89.53	39.86	89.35	40.25	89.18	40.64	89.00	41.03	98
99	90.44	40.27	90.26	40.66	90.09	41.05	89.91	41.45	99
100	91.35	40.67	91.18	41.07	91.00	41.47	90.81	41.87	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	66 Deg.		65¾ Deg.		65½ Deg.		65¼ Deg.		

Distance.	25 Deg.		25¼ Deg.		25½ Deg.		25¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.91	0.42	0.90	0.43	0.90	0.43	0.90	0.43	1
2	1.81	0.85	1.81	0.85	1.81	0.86	1.80	0.87	2
3	2.72	1.27	2.71	1.28	2.71	1.29	2.70	1.30	3
4	3.63	1.69	3.62	1.71	3.61	1.72	3.60	1.74	4
5	4.53	2.11	4.52	2.13	4.51	2.15	4.50	2.17	5
6	5.44	2.54	5.43	2.56	5.42	2.58	5.40	2.61	6
7	6.34	2.96	6.33	2.99	6.32	3.01	6.30	3.04	7
8	7.25	3.38	7.24	3.41	7.22	3.44	7.21	3.48	8
9	8.16	3.80	8.14	3.84	8.12	3.87	8.11	3.91	9
10	9.06	4.23	9.04	4.27	9.03	4.31	9.01	4.34	10
11	9.97	4.65	9.95	4.69	9.93	4.74	9.91	4.78	11
12	10.88	5.07	10.85	5.12	10.83	5.17	10.81	5.21	12
13	11.78	5.49	11.76	5.55	11.73	5.60	11.71	5.65	13
14	12.69	5.92	12.66	5.97	12.64	6.03	12.61	6.08	14
15	13.59	6.34	13.57	6.40	13.54	6.46	13.51	6.52	15
16	14.50	6.76	14.47	6.83	14.44	6.89	14.41	6.95	16
17	15.41	7.18	15.38	7.25	15.34	7.32	15.31	7.39	17
18	16.31	7.61	16.28	7.68	16.25	7.75	16.21	7.82	18
19	17.22	8.03	17.18	8.10	17.15	8.18	17.11	8.25	19
20	18.13	8.45	18.09	8.53	18.05	8.61	18.01	8.69	20
21	19.03	8.87	18.99	8.96	18.95	9.04	18.91	9.12	21
22	19.94	9.30	19.90	9.38	19.86	9.47	19.82	9.56	22
23	20.85	9.72	20.80	9.81	20.76	9.90	20.72	9.99	23
24	21.75	10.14	21.71	10.24	21.66	10.33	21.62	10.43	24
25	22.66	10.57	22.61	10.66	22.56	10.76	22.52	10.86	25
26	23.56	10.99	23.52	11.09	23.47	11.19	23.42	11.30	26
27	24.47	11.41	24.42	11.52	24.37	11.62	24.32	11.73	27
28	25.38	11.83	25.32	11.94	25.27	12.05	25.22	12.16	28
29	26.28	12.26	26.23	12.37	26.17	12.48	26.12	12.60	29
30	27.19	12.68	27.13	12.80	27.08	12.92	27.02	13.03	30
31	28.10	13.10	28.04	13.22	27.98	13.35	27.92	13.47	31
32	29.00	13.52	28.94	13.65	28.88	13.78	28.82	13.90	32
33	29.91	13.95	29.85	14.08	29.79	14.21	29.72	14.34	33
34	30.81	14.37	30.75	14.50	30.69	14.64	30.62	14.77	34
35	31.72	14.79	31.66	14.93	31.59	15.07	31.52	15.21	35
36	32.63	15.21	32.56	15.36	32.49	15.50	32.43	15.64	36
37	33.53	15.64	33.46	15.78	33.40	15.93	33.33	16.07	37
38	34.44	16.06	34.37	16.21	34.30	16.36	34.23	16.51	38
39	35.35	16.48	35.27	16.64	35.20	16.79	35.13	16.94	39
40	36.25	16.90	36.18	17.06	36.10	17.22	36.03	17.38	40
41	37.16	17.33	37.08	17.49	37.01	17.65	36.93	17.81	41
42	38.06	17.75	37.99	17.92	37.91	18.08	37.83	18.25	42
43	38.97	18.17	38.89	18.34	38.81	18.51	38.73	18.68	43
44	39.88	18.60	39.80	18.77	39.71	18.94	39.63	19.12	44
45	40.78	19.02	40.70	19.20	40.62	19.37	40.53	19.55	45
46	41.69	19.44	41.60	19.62	41.52	19.80	41.43	19.98	46
47	42.60	19.86	42.51	20.05	42.42	20.23	42.33	20.42	47
48	43.50	20.29	43.41	20.48	43.32	20.66	43.23	20.85	48
49	44.41	20.71	44.32	20.90	44.23	21.10	44.13	21.29	49
50	45.32	21.13	45.22	21.33	45.13	21.53	45.03	21.72	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	65 Deg.		64¾ Deg.		64½ Deg.		64¼ Deg.		

Distance.	25 Deg.		25¼ Deg.		25½ Deg.		25¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	46.22	21.55	46.13	21.75	46.03	21.96	45.94	22.16	51
52	47.13	21.98	47.03	22.18	46.93	22.39	46.84	22.59	52
53	48.03	22.40	47.94	22.61	47.84	22.82	47.74	23.03	53
54	48.94	22.82	48.84	23.03	48.74	23.25	48.64	23.46	54
55	49.85	23.24	49.74	23.46	49.64	23.68	49.54	23.89	55
56	50.75	23.67	50.65	23.89	50.54	24.11	50.44	24.33	56
57	51.66	24.09	51.55	24.31	51.45	24.54	51.34	24.76	57
58	52.57	24.51	52.46	24.74	52.35	24.97	52.24	25.20	58
59	53.47	24.93	53.36	25.17	53.25	25.40	53.14	25.63	59
60	54.38	25.36	54.27	25.59	54.16	25.83	54.04	26.07	60
61	55.28	25.78	55.17	26.02	55.06	26.26	54.94	26.50	61
62	56.19	26.20	56.08	26.45	55.96	26.69	55.84	26.94	62
63	57.10	26.62	56.98	26.87	56.86	27.12	56.74	27.37	63
64	58.00	27.05	57.89	27.30	57.77	27.55	57.64	27.80	64
65	58.91	27.47	58.79	27.73	58.67	27.98	58.55	28.24	65
66	59.82	27.89	59.69	28.15	59.57	28.41	59.45	28.67	66
67	60.72	28.32	60.60	28.58	60.47	28.84	60.35	29.11	67
68	61.63	28.74	61.50	29.01	61.38	29.27	61.25	29.54	68
69	62.54	29.16	62.41	29.43	62.28	29.71	62.15	29.98	69
70	63.44	29.58	63.31	29.86	63.18	30.14	63.05	30.41	70
71	64.35	30.01	64.22	30.29	64.08	30.57	63.95	30.85	71
72	65.25	30.43	65.12	30.71	64.99	31.00	64.85	31.28	72
73	66.16	30.85	66.03	31.14	65.89	31.43	65.75	31.71	73
74	67.07	31.27	66.93	31.57	66.79	31.86	66.65	32.15	74
75	67.97	31.70	67.83	31.99	67.69	32.29	67.55	32.58	75
76	68.88	32.12	68.74	32.42	68.60	32.72	68.45	33.02	76
77	69.79	32.54	69.64	32.85	69.50	33.15	69.35	33.45	77
78	70.69	32.96	70.55	33.27	70.40	33.58	70.25	33.89	78
79	71.60	33.39	71.45	33.70	71.30	34.01	71.16	34.32	79
80	72.50	33.81	72.36	34.13	72.21	34.44	72.06	34.76	80
81	73.41	34.23	73.26	34.55	73.11	34.87	72.96	35.19	81
82	74.32	34.65	74.17	34.98	74.01	35.30	73.86	35.62	82
83	75.22	35.08	75.07	35.41	74.91	35.73	74.76	36.06	83
84	76.13	35.50	75.97	35.83	75.82	36.16	75.66	36.49	84
85	77.04	35.92	76.88	36.26	76.72	36.59	76.56	36.93	85
86	77.94	36.35	77.78	36.68	77.62	37.02	77.46	37.36	86
87	78.85	36.77	78.69	37.11	78.52	37.46	78.36	37.80	87
88	79.76	37.19	79.59	37.54	79.43	37.88	79.26	38.23	88
89	80.66	37.61	80.50	37.96	80.33	38.32	80.16	38.67	89
90	81.57	38.04	81.40	38.39	81.23	38.75	81.06	39.10	90
91	82.47	38.46	82.31	38.82	82.14	39.18	81.96	39.53	91
92	83.38	38.88	83.21	39.24	83.04	39.61	82.86	39.97	92
93	84.29	39.30	84.11	39.67	83.94	40.04	83.76	40.40	93
94	85.19	39.73	85.02	40.10	84.84	40.47	84.67	40.84	94
95	86.10	40.15	85.92	40.52	85.75	40.90	85.57	41.27	95
96	87.01	40.57	86.83	40.95	86.65	41.33	86.47	41.71	96
97	87.91	40.99	87.73	41.38	87.55	41.76	87.37	42.14	97
98	88.82	41.42	88.64	41.80	88.45	42.19	88.27	42.58	98
99	89.72	41.84	89.54	42.23	89.36	42.62	89.17	43.01	99
100	90.63	42.26	90.45	42.66	90.26	43.05	90.07	43.44	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	65 Deg.		64¾ Deg.		64½ Deg.		64¼ Deg.		

Distance.	26 Deg.		26¼ Deg.		26½ Deg.		26¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.90	0.44	0.90	0.44	0.89	0.45	0.89	0.45	1
2	1.80	0.88	1.79	0.88	1.79	0.89	1.79	0.90	2
3	2.70	1.32	2.69	1.33	2.68	1.34	2.68	1.35	3
4	3.60	1.75	3.59	1.77	3.58	1.78	3.57	1.80	4
5	4.49	2.19	4.48	2.21	4.47	2.23	4.46	2.25	5
6	5.39	2.63	5.38	2.65	5.37	2.68	5.36	2.70	6
7	6.29	3.07	6.28	3.10	6.26	3.12	6.25	3.15	7
8	7.19	3.51	7.17	3.54	7.16	3.57	7.14	3.60	8
9	8.09	3.95	8.07	3.98	8.05	4.02	8.04	4.05	9
10	8.99	4.38	8.97	4.42	8.95	4.46	8.93	4.50	10
11	9.89	4.82	9.87	4.87	9.84	4.91	9.82	4.95	11
12	10.79	5.26	10.76	5.31	10.74	5.35	10.72	5.40	12
13	11.68	5.70	11.66	5.75	11.63	5.80	11.61	5.85	13
14	12.58	6.14	12.56	6.19	12.53	6.25	12.50	6.30	14
15	13.48	6.58	13.45	6.63	13.42	6.69	13.39	6.75	15
16	14.38	7.01	14.35	7.08	14.32	7.14	14.29	7.20	16
17	15.28	7.45	15.25	7.52	15.21	7.59	15.18	7.65	17
18	16.18	7.89	16.14	7.96	16.11	8.03	16.07	8.10	18
19	17.08	8.33	17.04	8.40	17.00	8.48	16.97	8.55	19
20	17.98	8.77	17.94	8.85	17.90	8.92	17.86	9.00	20
21	18.87	9.21	18.83	9.29	18.79	9.37	18.75	9.45	21
22	19.77	9.64	19.73	9.73	19.69	9.82	19.65	9.90	22
23	20.67	10.08	20.63	10.17	20.58	10.26	20.54	10.35	23
24	21.57	10.52	21.52	10.61	21.48	10.71	21.43	10.80	24
25	22.47	10.96	22.42	11.06	22.37	11.15	22.32	11.25	25
26	23.37	11.40	23.32	11.50	23.27	11.60	23.22	11.70	26
27	24.27	11.84	24.22	11.94	24.16	12.05	24.11	12.15	27
28	25.17	12.27	25.11	12.38	25.06	12.49	25.00	12.60	28
29	26.06	12.71	26.01	12.83	25.95	12.94	25.90	13.05	29
30	26.96	13.15	26.91	13.27	26.85	13.39	26.79	13.50	30
31	27.86	13.59	27.80	13.71	27.74	13.83	27.68	13.95	31
32	28.76	14.03	28.70	14.15	28.64	14.28	28.58	14.40	32
33	29.66	14.47	29.60	14.60	29.53	14.72	29.47	14.85	33
34	30.56	14.90	30.49	15.04	30.43	15.17	30.36	15.30	34
35	31.46	15.34	31.39	15.48	31.32	15.62	31.25	15.75	35
36	32.36	15.78	32.29	15.92	32.22	16.06	32.15	16.20	36
37	33.26	16.22	33.18	16.36	33.11	16.51	33.04	16.65	37
38	34.15	16.66	34.08	16.81	34.01	16.96	33.93	17.10	38
39	35.05	17.10	34.98	17.25	34.90	17.40	34.83	17.55	39
40	35.95	17.53	35.87	17.69	35.80	17.85	35.72	18.00	40
41	36.85	17.97	36.77	18.13	36.69	18.29	36.61	18.45	41
42	37.75	18.41	37.67	18.58	37.59	18.74	37.51	18.90	42
43	38.65	18.85	38.57	19.02	38.48	19.19	38.40	19.35	43
44	39.55	19.29	39.46	19.46	39.38	19.63	39.29	19.80	44
45	40.45	19.73	40.36	19.90	40.27	20.08	40.18	20.25	45
46	41.34	20.17	41.26	20.35	41.17	20.53	41.08	20.70	46
47	42.24	20.60	42.15	20.79	42.06	20.97	41.97	21.15	47
48	43.14	21.04	43.05	21.23	42.96	21.42	42.86	21.60	48
49	44.04	21.48	43.95	21.67	43.85	21.86	43.76	22.05	49
50	44.94	21.92	44.84	22.11	44.75	22.31	44.65	22.50	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	64 Deg.		63¾ Deg.		63½ Deg.		63¼ Deg.		

Distance.	26 Deg.		26¼ Deg.		26½ Deg.		26¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	45.84	22.36	45.74	22.56	45.64	22.76	45.54	22.96	51
52	46.74	22.80	46.64	23.00	46.54	23.20	46.43	23.41	52
53	47.64	23.23	47.53	23.44	47.43	23.65	47.33	23.86	53
54	48.53	23.67	48.43	23.88	48.33	24.09	48.22	24.31	54
55	49.43	24.11	49.33	24.33	49.22	24.54	49.11	24.76	55
56	50.33	24.55	50.22	24.77	50.12	24.99	50.01	25.21	56
57	51.23	24.99	51.12	25.21	51.01	25.43	50.90	25.66	57
58	52.13	25.43	52.02	25.65	51.91	25.88	51.79	26.11	58
59	53.03	25.86	52.92	26.09	52.80	26.33	52.69	26.56	59
60	53.93	26.30	53.81	26.54	53.70	26.77	53.58	27.01	60
61	54.83	26.74	54.71	26.98	54.59	27.22	54.47	27.46	61
62	55.73	27.18	55.61	27.42	55.49	27.66	55.36	27.91	62
63	56.62	27.62	56.50	27.86	56.38	28.11	56.26	28.36	63
64	57.52	28.06	57.40	28.31	57.28	28.56	57.15	28.81	64
65	58.42	28.49	58.30	28.75	58.17	29.00	58.04	29.26	65
66	59.32	28.93	59.19	29.19	59.07	29.45	58.94	29.71	66
67	60.22	29.37	60.09	29.63	59.96	29.90	59.83	30.16	67
68	61.12	29.81	60.99	30.08	60.86	30.34	60.72	30.61	68
69	62.02	30.25	61.88	30.52	61.75	30.79	61.62	31.06	69
70	62.92	30.69	62.78	30.96	62.65	31.23	62.51	31.51	70
71	63.81	31.12	63.68	31.40	63.54	31.68	63.40	31.96	71
72	64.71	31.56	64.57	31.84	64.44	32.13	64.29	32.41	72
73	65.61	32.00	65.47	32.29	65.33	32.57	65.19	32.86	73
74	66.51	32.44	66.37	32.73	66.23	33.02	66.08	33.31	74
75	67.41	32.88	67.27	33.17	67.12	33.46	66.97	33.76	75
76	68.31	33.32	68.16	33.61	68.01	33.91	67.87	34.21	76
77	69.21	33.75	69.06	34.06	68.91	34.36	68.76	34.66	77
78	70.11	34.19	69.96	34.50	69.80	34.80	69.65	35.11	78
79	71.00	34.63	70.85	34.94	70.70	35.25	70.55	35.56	79
80	71.90	35.07	71.75	35.38	71.59	35.70	71.44	36.01	80
81	72.80	35.51	72.65	35.83	72.49	36.14	72.33	36.46	81
82	73.70	35.95	73.54	36.27	73.38	36.59	73.22	36.91	82
83	74.60	36.38	74.44	36.71	74.28	37.03	74.12	37.36	83
84	75.50	36.82	75.34	37.15	75.17	37.48	75.01	37.81	84
85	76.40	37.26	76.23	37.59	76.07	37.93	75.90	38.26	85
86	77.30	37.70	77.13	38.04	76.96	38.37	76.80	38.71	86
87	78.20	38.14	78.03	38.48	77.86	38.82	77.69	39.16	87
88	79.09	38.58	78.92	38.92	78.75	39.27	78.58	39.61	88
89	79.99	39.01	79.82	39.36	79.65	39.71	79.48	40.06	89
90	80.89	39.45	80.72	39.81	80.54	40.16	80.37	40.51	90
91	81.79	39.89	81.62	40.25	81.44	40.60	81.26	40.96	91
92	82.69	40.33	82.51	40.69	82.33	41.05	82.15	41.41	92
93	83.59	40.77	83.41	41.13	83.23	41.50	83.05	41.86	93
94	84.49	41.21	84.31	41.58	84.12	41.94	83.94	42.31	94
95	85.39	41.65	85.20	42.02	85.02	42.39	84.83	42.76	95
96	86.28	42.08	86.10	42.46	85.91	42.83	85.73	43.21	96
97	87.18	42.52	87.00	42.90	86.81	43.28	86.62	43.66	97
98	88.08	42.96	87.89	43.34	87.70	43.73	87.51	44.11	98
99	88.98	43.40	88.79	43.79	88.60	44.17	88.40	44.56	99
100	89.88	43.84	89.69	44.23	89.49	44.62	89.30	45.01	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	64 Deg.		63¾ Deg.		63½ Deg.		63¼ Deg.		

Distance.	27 Deg.		27¼ Deg.		27½ Deg.		27¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	
1	0.89	0.45	0.89	0.46	0.89	0.46	0.88	0.47	1
2	1.78	0.91	1.78	0.92	1.77	0.92	1.77	0.93	2
3	2.67	1.36	2.67	1.37	2.66	1.39	2.65	1.40	3
4	3.56	1.82	3.56	1.83	3.55	1.85	3.54	1.86	4
5	4.45	2.27	4.45	2.29	4.44	2.31	4.42	2.33	5
6	5.35	2.72	5.33	2.75	5.32	2.77	5.31	2.79	6
7	6.24	3.18	6.22	3.21	6.21	3.23	6.19	3.26	7
8	7.13	3.63	7.11	3.66	7.10	3.69	7.08	3.72	8
9	8.02	4.09	8.00	4.12	7.98	4.16	7.96	4.19	9
10	8.91	4.54	8.89	4.58	8.87	4.62	8.85	4.66	10
11	9.80	4.99	9.78	5.04	9.76	5.08	9.73	5.12	11
12	10.69	5.45	10.67	5.49	10.64	5.54	10.62	5.59	12
13	11.58	5.90	11.56	5.95	11.53	6.00	11.50	6.05	13
14	12.47	6.36	12.45	6.41	12.42	6.46	12.39	6.52	14
15	13.37	6.81	13.34	6.87	13.31	6.93	13.27	6.98	15
16	14.26	7.26	14.22	7.33	14.19	7.39	14.16	7.45	16
17	15.15	7.72	15.11	7.78	15.08	7.85	15.04	7.92	17
18	16.04	8.17	16.00	8.24	15.97	8.31	15.93	8.38	18
19	16.93	8.63	16.89	8.70	16.85	8.77	16.81	8.85	19
20	17.82	9.08	17.78	9.16	17.74	9.23	17.70	9.31	20
21	18.71	9.53	18.67	9.62	18.63	9.70	18.58	9.78	21
22	19.60	9.99	19.56	10.07	19.51	10.16	19.47	10.24	22
23	20.49	10.44	20.45	10.53	20.40	10.62	20.35	10.71	23
24	21.38	10.90	21.34	10.99	21.29	11.08	21.24	11.17	24
25	22.28	11.35	22.23	11.45	22.18	11.54	22.12	11.64	25
26	23.17	11.80	23.11	11.90	23.06	12.01	23.01	12.11	26
27	24.06	12.26	24.00	12.36	23.95	12.47	23.89	12.57	27
28	24.95	12.71	24.89	12.82	24.84	12.93	24.78	13.04	28
29	25.84	13.17	25.78	13.28	25.72	13.39	25.66	13.50	29
30	26.73	13.62	26.67	13.74	26.61	13.85	26.55	13.97	30
31	27.62	14.07	27.56	14.19	27.50	14.31	27.43	14.43	31
32	28.51	14.53	28.45	14.65	28.38	14.78	28.32	14.90	32
33	29.40	14.98	29.34	15.11	29.27	15.24	29.20	15.37	33
34	30.29	15.44	30.23	15.57	30.16	15.70	30.09	15.83	34
35	31.19	15.89	31.12	16.03	31.05	16.16	30.97	16.30	35
36	32.08	16.34	32.00	16.48	31.93	16.62	31.86	16.76	36
37	32.97	16.80	32.89	16.94	32.82	17.08	32.74	17.23	37
38	33.86	17.25	33.78	17.40	33.71	17.55	33.63	17.69	38
39	34.75	17.71	34.67	17.86	34.59	18.01	34.51	18.16	39
40	35.64	18.16	35.56	18.31	35.48	18.47	35.40	18.62	40
41	36.53	18.61	36.45	18.77	36.37	18.93	36.28	19.09	41
42	37.42	19.07	37.34	19.23	37.25	19.39	37.17	19.56	42
43	38.31	19.52	38.23	19.69	38.14	19.86	38.05	20.02	43
44	39.20	19.98	39.12	20.15	39.03	20.32	38.94	20.49	44
45	40.10	20.43	40.01	20.60	39.92	20.78	39.82	20.95	45
46	40.99	20.88	40.89	21.06	40.80	21.24	40.71	21.42	46
47	41.88	21.34	41.78	21.52	41.69	21.70	41.59	21.88	47
48	42.77	21.79	42.67	21.98	42.58	22.16	42.48	22.35	48
49	43.66	22.25	43.56	22.44	43.46	22.63	43.36	22.82	49
50	44.55	22.70	44.45	22.89	44.35	23.09	44.25	23.28	50
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance.	63 Deg.		62¾ Deg.		62½ Deg.		62¼ Deg.		Distance.

Distance.	27 Deg.		27¼ Deg.		27½ Deg.		27¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	45.44	23.15	45.34	23.35	45.24	23.55	45.13	23.75	51
52	46.33	23.61	46.23	23.81	46.12	24.01	46.02	24.21	52
53	47.22	24.06	47.12	24.27	47.01	24.47	46.90	24.68	53
54	48.11	24.52	48.01	24.73	47.90	24.93	47.79	25.14	54
55	49.01	24.97	48.90	25.18	48.79	25.40	48.67	25.61	55
56	49.90	25.42	49.78	25.64	49.67	25.86	49.56	26.07	56
57	50.79	25.88	50.67	26.10	50.56	26.32	50.44	26.54	57
58	51.68	26.33	51.56	26.56	51.45	26.78	51.33	27.01	58
59	52.57	26.79	52.45	27.01	52.33	27.24	52.21	27.47	59
60	53.46	27.24	53.34	27.47	53.22	27.70	53.10	27.94	60
61	54.35	27.69	54.23	27.93	54.11	28.17	53.98	28.40	61
62	55.24	28.15	55.12	28.39	54.99	28.63	54.87	28.87	62
63	56.13	28.60	56.01	28.85	55.88	29.09	55.75	29.33	63
64	57.02	29.06	56.90	29.30	56.77	29.55	56.64	29.80	64
65	57.92	29.51	57.79	29.76	57.66	30.01	57.52	30.26	65
66	58.81	29.96	58.68	30.22	58.54	30.48	58.41	30.73	66
67	59.70	30.42	59.56	30.68	59.43	30.94	59.29	31.20	67
68	60.59	30.87	60.45	31.14	60.32	31.40	60.18	31.66	68
69	61.48	31.33	61.34	31.59	61.20	31.86	61.06	32.13	69
70	62.37	31.78	62.23	32.05	62.09	32.32	61.95	32.59	70
71	63.26	32.23	63.12	32.51	62.98	32.78	62.83	33.06	71
72	64.15	32.69	64.01	32.97	63.86	33.25	63.72	33.52	72
73	65.04	33.14	64.90	33.42	64.75	33.71	64.60	33.99	73
74	65.93	33.60	65.79	33.88	65.64	34.17	65.49	34.46	74
75	66.83	34.05	66.68	34.34	66.53	34.63	66.37	34.92	75
76	67.72	34.50	67.57	34.80	67.41	35.09	67.26	35.39	76
77	68.61	34.96	68.45	35.26	68.30	35.55	68.14	35.85	77
78	69.50	35.41	69.34	35.71	69.19	36.02	69.03	36.32	78
79	70.39	35.87	70.23	36.17	70.07	36.48	69.91	36.78	79
80	71.28	36.32	71.12	36.63	70.96	36.94	70.80	37.25	80
81	72.17	36.77	72.01	37.09	71.85	37.40	71.68	37.71	81
82	73.06	37.23	72.90	37.55	72.73	37.86	72.57	38.18	82
83	73.95	37.68	73.79	38.00	73.62	38.33	73.45	38.65	83
84	74.84	38.14	74.68	38.46	74.51	38.79	74.34	39.11	84
85	75.74	38.59	75.57	38.92	75.40	39.25	75.22	39.58	85
86	76.63	39.04	76.46	39.38	76.28	39.71	76.11	40.04	86
87	77.52	39.50	77.34	39.83	77.17	40.17	76.99	40.51	87
88	78.41	39.95	78.23	40.29	78.06	40.63	77.88	40.97	88
89	79.30	40.41	79.12	40.75	78.94	41.10	78.76	41.44	89
90	80.19	40.86	80.01	41.21	79.83	41.56	79.65	41.91	90
91	81.08	41.31	80.90	41.67	80.72	42.02	80.53	42.37	91
92	81.97	41.77	81.79	42.12	81.60	42.48	81.42	42.84	92
93	82.86	42.22	82.68	42.58	82.49	42.94	82.30	43.30	93
94	83.75	42.68	83.57	43.04	83.38	43.40	83.19	43.77	94
95	84.65	43.13	84.46	43.50	84.27	43.87	84.07	44.23	95
96	85.54	43.58	85.35	43.96	85.15	44.33	84.96	44.70	96
97	86.43	44.04	86.23	44.41	86.04	44.79	85.84	45.16	97
98	87.32	44.49	87.12	44.87	86.93	45.25	86.73	45.63	98
99	88.21	44.95	88.01	45.33	87.81	45.71	87.61	46.10	99
100	89.10	45.40	88.90	45.79	88.70	46.17	88.50	46.56	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	63 Deg.		62¾ Deg.		62½ Deg.		62¼ Deg.		

Distance.	28 Deg.		28¼ Deg.		28½ Deg.		28¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.88	0.47	0.88	0.47	0.88	0.48	0.88	0.48	1
2	1.77	0.94	1.76	0.95	1.76	0.95	1.75	0.96	2
3	2.65	1.41	2.64	1.42	2.64	1.43	2.63	1.44	3
4	3.53	1.88	3.52	1.89	3.52	1.91	3.51	1.92	4
5	4.41	2.35	4.40	2.37	4.39	2.39	4.38	2.40	5
6	5.30	2.82	5.29	2.84	5.27	2.86	5.26	2.89	6
7	6.18	3.29	6.17	3.31	6.15	3.34	6.14	3.37	7
8	7.06	3.76	7.05	3.79	7.03	3.82	7.01	3.85	8
9	7.95	4.23	7.93	4.26	7.91	4.29	7.89	4.33	9
10	8.83	4.69	8.81	4.73	8.79	4.77	8.77	4.81	10
11	9.71	5.16	9.69	5.21	9.67	5.25	9.64	5.29	11
12	10.60	5.63	10.57	5.68	10.55	5.73	10.52	5.77	12
13	11.48	6.10	11.45	6.15	11.42	6.20	11.40	6.25	13
14	12.36	6.57	12.33	6.63	12.30	6.68	12.27	6.73	14
15	13.24	7.04	13.21	7.10	13.18	7.16	13.15	7.21	15
16	14.13	7.51	14.09	7.57	14.06	7.63	14.03	7.70	16
17	15.01	7.98	14.98	8.05	14.94	8.11	14.90	8.18	17
18	15.89	8.45	15.86	8.52	15.82	8.59	15.78	8.66	18
19	16.78	8.92	16.74	8.99	16.70	9.07	16.66	9.14	19
20	17.66	9.39	17.62	9.47	17.58	9.54	17.53	9.62	20
21	18.54	9.86	18.50	9.94	18.46	10.02	18.41	10.10	21
22	19.42	10.33	19.38	10.41	19.33	10.50	19.29	10.58	22
23	20.31	10.80	20.26	10.89	20.21	10.97	20.16	11.06	23
24	21.19	11.27	21.14	11.36	21.09	11.45	21.04	11.54	24
25	22.07	11.74	22.02	11.83	21.97	11.93	21.92	12.02	25
26	22.96	12.21	22.90	12.31	22.85	12.41	22.79	12.51	26
27	23.84	12.68	23.78	12.78	23.73	12.88	23.67	12.99	27
28	24.72	13.15	24.66	13.25	24.61	13.36	24.55	13.47	28
29	25.61	13.61	25.55	13.73	25.49	13.84	25.43	13.95	29
30	26.49	14.08	26.43	14.20	26.36	14.31	26.30	14.43	30
31	27.37	14.55	27.31	14.67	27.24	14.79	27.18	14.91	31
32	28.25	15.02	28.19	15.15	28.12	15.27	28.06	15.39	32
33	29.14	15.49	29.07	15.62	29.00	15.75	28.93	15.87	33
34	30.02	15.96	29.95	16.09	29.88	16.22	29.81	16.35	34
35	30.90	16.43	30.83	16.57	30.76	16.70	30.69	16.83	35
36	31.79	16.90	31.71	17.04	31.64	17.18	31.56	17.32	36
37	32.67	17.37	32.59	17.51	32.52	17.65	32.44	17.80	37
38	33.55	17.84	33.47	17.99	33.39	18.13	33.32	18.28	38
39	34.43	18.31	34.35	18.46	34.27	18.61	34.19	18.76	39
40	35.32	18.78	35.24	18.93	35.15	19.09	35.07	19.24	40
41	36.20	19.25	36.12	19.41	36.03	19.56	35.95	19.72	41
42	37.08	19.72	37.00	19.88	36.91	20.04	36.82	20.20	42
43	37.97	20.19	37.88	20.35	37.79	20.52	37.70	20.68	43
44	38.85	20.66	38.76	20.83	38.67	20.99	38.58	21.16	44
45	39.73	21.13	39.64	21.30	39.55	21.47	39.45	21.64	45
46	40.62	21.60	40.52	21.77	40.43	21.95	40.33	22.13	46
47	41.50	22.07	41.40	22.25	41.30	22.43	41.21	22.61	47
48	42.38	22.53	42.28	22.72	42.18	22.90	42.08	23.09	48
49	43.26	23.00	43.16	23.19	43.06	23.38	42.96	23.57	49
50	44.15	23.47	44.04	23.67	43.94	23.86	43.84	24.05	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	62 Deg.		61¾ Deg.		61½ Deg.		61¼ Deg.		

Distance.	28 Deg.		28¼ Deg.		28½ Deg.		28¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	45.03	23.94	44.93	24.14	44.82	24.34	44.71	24.53	51
52	45.91	24.41	45.81	24.61	45.70	24.81	45.59	25.01	52
53	46.80	24.88	46.69	25.09	46.58	25.29	46.47	25.49	53
54	47.68	25.35	47.57	25.56	47.46	25.77	47.34	25.97	54
55	48.56	25.82	48.45	26.03	48.33	26.24	48.22	26.45	55
56	49.45	26.29	49.33	26.51	49.21	26.72	49.10	26.94	56
57	50.33	26.76	50.21	26.98	50.09	27.20	49.97	27.42	57
58	51.21	27.23	51.09	27.45	50.97	27.68	50.85	27.90	58
59	52.09	27.70	51.97	27.93	51.85	28.15	51.73	28.38	59
60	52.98	28.17	52.85	28.40	52.73	28.63	52.60	28.86	60
61	53.86	28.64	53.73	28.87	53.61	29.11	53.48	29.34	61
62	54.74	29.11	54.62	29.35	54.49	29.58	54.36	29.82	62
63	55.63	29.58	55.50	29.82	55.37	30.06	55.23	30.30	63
64	56.51	30.05	56.38	30.29	56.24	30.54	56.11	30.78	64
65	57.39	30.52	57.26	30.77	57.12	31.02	56.99	31.26	65
66	58.27	30.99	58.14	31.24	58.00	31.49	57.86	31.75	66
67	59.16	31.45	59.02	31.71	58.88	31.97	58.74	32.23	67
68	60.04	31.92	59.90	32.19	59.76	32.45	59.62	32.71	68
69	60.92	32.39	60.78	32.66	60.64	32.92	60.49	33.19	69
70	61.81	32.86	61.66	33.13	61.52	33.40	61.37	33.67	70
71	62.69	33.33	62.54	33.61	62.40	33.88	62.25	34.15	71
72	63.57	33.80	63.42	34.08	63.27	34.36	63.12	34.63	72
73	64.46	34.27	64.30	34.55	64.15	34.83	64.00	35.11	73
74	65.34	34.74	65.19	35.03	65.03	35.31	64.88	35.59	74
75	66.22	35.21	66.07	35.50	65.91	35.79	65.75	36.07	75
76	67.10	35.68	66.95	35.97	66.79	36.26	66.63	36.56	76
77	67.99	36.15	67.83	36.45	67.67	36.74	67.51	37.04	77
78	68.87	36.62	68.71	36.92	68.55	37.22	68.38	37.52	78
79	69.75	37.09	69.59	37.39	69.43	37.70	69.26	38.00	79
80	70.64	37.56	70.47	37.87	70.31	38.17	70.14	38.48	80
81	71.52	38.03	71.35	38.34	71.18	38.65	71.01	38.96	81
82	72.40	38.50	72.23	38.81	72.06	39.13	71.89	39.44	82
83	73.28	38.97	73.11	39.29	72.94	39.60	72.77	39.92	83
84	74.17	39.44	73.99	39.76	73.82	40.08	73.64	40.40	84
85	75.05	39.91	74.88	40.23	74.70	40.56	74.52	40.88	85
86	75.93	40.37	75.76	40.71	75.58	41.04	75.40	41.36	86
87	76.82	40.84	76.64	41.18	76.46	41.51	76.28	41.85	87
88	77.70	41.31	77.52	41.65	77.34	41.99	77.15	42.33	88
89	78.58	41.78	78.40	42.13	78.21	42.47	78.03	42.81	89
90	79.47	42.25	79.28	42.60	79.09	42.94	78.91	43.29	90
91	80.35	42.72	80.16	43.07	79.97	43.42	79.78	43.77	91
92	81.23	43.19	81.04	43.55	80.85	43.90	80.66	44.25	92
93	82.11	43.66	81.92	44.02	81.73	44.38	81.54	44.73	93
94	83.00	44.13	82.80	44.49	82.61	44.85	82.41	45.21	94
95	83.88	44.60	83.68	44.97	83.49	45.33	83.29	45.69	95
96	84.76	45.07	84.57	45.44	84.37	45.81	84.17	46.17	96
97	85.65	45.54	85.45	45.91	85.25	46.28	85.04	46.66	97
98	86.53	46.01	86.33	46.39	86.12	46.76	85.92	47.14	98
99	87.41	46.48	87.21	46.86	87.00	47.24	86.80	47.62	99
100	88.29	46.95	88.09	47.33	87.88	47.72	87.67	48.10	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	62 Deg.		61¾ Deg.		61½ Deg.		61¼ Deg.		

Distance.	29 Deg. Lat.	29 Deg. Dep.	29¼ Deg. Lat.	29¼ Deg. Dep.	29½ Deg. Lat.	29½ Deg. Dep.	29¾ Deg. Lat.	29¾ Deg. Dep.	Distance.
1	0.87	0.48	0.87	0.49	0.87	0.49	0.87	0.50	1
2	1.75	0.97	1.74	0.98	1.74	0.98	1.74	0.99	2
3	2.62	1.45	2.62	1.47	2.61	1.48	2.60	1.49	3
4	3.50	1.94	3.49	1.95	3.48	1.97	3.47	1.98	4
5	4.37	2.42	4.36	2.44	4.35	2.46	4.34	2.48	5
6	5.25	2.91	5.23	2.93	5.22	2.95	5.21	2.98	6
7	6.12	3.39	6.11	3.42	6.09	3.45	6.08	3.47	7
8	7.00	3.88	6.98	3.91	6.96	3.94	6.95	3.97	8
9	7.87	4.36	7.85	4.40	7.83	4.43	7.81	4.47	9
10	8.75	4.85	8.72	4.89	8.70	4.92	8.68	4.96	10
11	9.62	5.33	9.60	5.37	9.57	5.42	9.55	5.46	11
12	10.50	5.82	10.47	5.86	10.44	5.91	10.42	5.95	12
13	11.37	6.30	11.34	6.35	11.31	6.40	11.29	6.45	13
14	12.24	6.79	12.21	6.84	12.18	6.89	12.15	6.95	14
15	13.12	7.27	13.09	7.33	13.06	7.39	13.02	7.44	15
16	13.99	7.76	13.96	7.82	13.93	7.88	13.89	7.94	16
17	14.87	8.24	14.83	8.31	14.80	8.37	14.76	8.44	17
18	15.74	8.73	15.70	8.80	15.67	8.86	15.63	8.93	18
19	16.62	9.21	16.58	9.28	16.54	9.36	16.50	9.43	19
20	17.49	9.70	17.45	9.77	17.41	9.85	17.36	9.92	20
21	18.37	10.18	18.32	10.26	18.28	10.34	18.23	10.42	21
22	19.24	10.67	19.19	10.75	19.15	10.83	19.10	10.92	22
23	20.12	11.15	20.07	11.24	20.02	11.33	19.97	11.41	23
24	20.99	11.64	20.94	11.73	20.89	11.82	20.84	11.91	24
25	21.87	12.12	21.81	12.22	21.76	12.31	21.70	12.41	25
26	22.74	12.60	22.68	12.70	22.63	12.80	22.57	12.90	26
27	23.61	13.09	23.56	13.19	23.50	13.30	23.44	13.40	27
28	24.49	13.57	24.43	13.68	24.37	13.79	24.31	13.89	28
29	25.36	14.06	25.30	14.17	25.24	14.28	25.18	14.39	29
30	26.24	14.54	26.17	14.66	26.11	14.77	26.05	14.89	30
31	27.11	15.03	27.05	15.15	26.98	15.27	26.91	15.38	31
32	27.99	15.51	27.92	15.64	27.85	15.76	27.78	15.88	32
33	28.86	16.00	28.79	16.12	28.72	16.25	28.65	16.38	33
34	29.74	16.48	29.66	16.61	29.59	16.74	29.52	16.87	34
35	30.61	16.97	30.54	17.10	30.46	17.23	30.39	17.37	35
36	31.49	17.45	31.41	17.59	31.33	17.73	31.26	17.86	36
37	32.36	17.94	32.28	18.08	32.20	18.22	32.12	18.36	37
38	33.24	18.42	33.15	18.57	33.07	18.71	32.99	18.86	38
39	34.11	18.91	34.03	19.06	33.94	19.20	33.86	19.35	39
40	34.98	19.39	34.90	19.54	34.81	19.70	34.73	19.85	40
41	35.86	19.88	35.77	20.03	35.68	20.19	35.60	20.34	41
42	36.73	20.36	36.64	20.52	36.55	20.68	36.46	20.84	42
43	37.61	20.85	37.52	21.01	37.43	21.17	37.33	21.34	43
44	38.48	21.33	38.39	21.50	38.30	21.67	38.20	21.83	44
45	39.36	21.82	39.26	21.99	39.17	22.16	39.07	22.33	45
46	40.23	22.30	40.13	22.48	40.04	22.65	39.94	22.83	46
47	41.11	22.79	41.01	22.97	40.91	23.14	40.81	23.32	47
48	41.98	23.27	41.88	23.45	41.78	23.63	41.67	23.82	48
49	42.86	23.76	42.75	23.94	42.65	24.13	42.54	24.31	49
50	43.73	24.24	43.62	24.43	43.52	24.62	43.41	24.81	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	61 Deg.		60¾ Deg.		60½ Deg.		60¼ Deg.		

Distance.	29 Deg.		29¼ Deg.		29½ Deg.		29¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	44.61	24.73	44.50	24.92	44.39	25.11	44.28	25.31	51
52	45.48	25.21	45.37	25.41	45.26	25.61	45.15	25.80	52
53	46.35	25.69	46.24	25.90	46.13	26.10	46.01	26.30	53
54	47.23	26.18	47.11	26.39	47.00	26.59	46.88	26.80	54
55	48.10	26.66	47.99	26.87	47.87	27.08	47.75	27.29	55
56	48.98	27.15	48.86	27.36	48.74	27.58	48.62	27.79	56
57	49.85	27.63	49.73	27.85	49.61	28.07	49.49	28.28	57
58	50.73	28.12	50.60	28.34	50.48	28.56	50.36	28.78	58
59	51.60	28.60	51.48	28.83	51.35	29.05	51.22	29.28	59
60	52.48	29.09	52.35	29.32	52.22	29.55	52.09	29.77	60
61	53.35	29.57	53.22	29.81	53.09	30.04	52.96	30.27	61
62	54.23	30.06	54.09	30.29	53.96	30.53	53.83	30.77	62
63	55.10	30.54	54.97	30.78	54.83	31.02	54.70	31.26	63
64	55.98	31.03	55.84	31.27	55.70	31.52	55.56	31.76	64
65	56.85	31.51	56.71	31.76	56.57	32.01	56.43	32.25	65
66	57.72	32.00	57.58	32.25	57.44	32.50	57.30	32.75	66
67	58.60	32.48	58.46	32.74	58.31	32.99	58.17	33.25	67
68	59.47	32.97	59.33	33.23	59.18	33.48	59.04	33.74	68
69	60.35	33.45	60.20	33.71	60.05	33.98	59.91	34.24	69
70	61.22	33.94	61.07	34.20	60.92	34.47	60.77	34.74	70
71	62.10	34.42	61.95	34.69	61.80	34.96	61.64	35.23	71
72	62.97	34.91	62.82	35.18	62.67	35.45	62.51	35.73	72
73	63.85	35.39	63.69	35.67	63.54	35.95	63.38	36.22	73
74	64.72	35.88	64.56	36.16	64.41	36.44	64.25	36.72	74
75	65.60	36.36	65.44	36.65	65.28	36.93	65.11	37.22	75
76	66.47	36.85	66.31	37.14	66.15	37.42	65.98	37.71	76
77	67.35	37.33	67.18	37.62	67.02	37.92	66.85	38.21	77
78	68.22	37.82	68.05	38.11	67.89	38.41	67.72	38.70	78
79	69.09	38.30	68.93	38.60	68.76	38.90	68.59	39.20	79
80	69.97	38.78	69.80	39.09	69.63	39.39	69.46	39.70	80
81	70.84	39.27	70.67	39.58	70.50	39.89	70.32	40.19	81
82	71.72	39.75	71.54	40.07	71.37	40.38	71.19	40.69	82
83	72.59	40.24	72.42	40.56	72.24	40.87	72.06	41.19	83
84	73.47	40.72	73.29	41.04	73.11	41.36	72.93	41.68	84
85	74.34	41.21	74.16	41.53	73.98	41.86	73.80	42.18	85
86	75.22	41.69	75.03	42.02	74.85	42.35	74.67	42.67	86
87	76.09	42.18	75.91	42.51	75.72	42.84	75.53	43.17	87
88	76.97	42.65	76.78	43.00	76.59	43.33	76.40	43.67	88
89	77.84	43.15	77.65	43.49	77.46	43.83	77.27	44.16	89
90	78.72	43.63	78.52	43.98	78.33	44.32	78.14	44.66	90
91	79.59	44.12	79.40	44.46	79.20	44.81	79.01	45.16	91
92	80.46	44.60	80.27	44.95	80.07	45.30	79.87	45.65	92
93	81.34	45.09	81.14	45.44	80.94	45.80	80.74	46.15	93
94	82.21	45.57	82.01	45.93	81.81	46.29	81.61	46.64	94
95	83.09	46.06	82.89	46.42	82.68	46.78	82.48	47.14	95
96	83.96	46.54	83.76	46.91	83.55	47.27	83.35	47.64	96
97	84.84	47.03	84.63	47.40	84.42	47.77	84.22	48.13	97
98	85.71	47.51	85.50	47.88	85.29	48.26	85.08	48.63	98
99	86.59	48.00	86.38	48.37	86.17	48.75	85.95	49.13	99
100	87.46	48.48	97.25	48.86	87.04	49.24	86.82	49.62	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	61 Deg.		60¾ Deg.		60½ Deg.		60¼ Deg.		

Distance.	30 Deg.		30¼ Deg.		30½ Deg.		30¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.87	0.50	0.86	0.50	0.86	0.51	0.86	0.51	1
2	1.73	1.00	1.73	1.01	1.72	1.02	1.72	1.02	2
3	2.60	1.50	2.59	1.51	2.58	1.52	2.58	1.53	3
4	3.46	2.00	3.46	2.02	3.45	2.03	3.44	2.05	4
5	4.33	2.50	4.32	2.52	4.31	2.54	4.30	2.56	5
6	5.20	3.00	5.18	3.02	5.17	3.05	5.16	3.07	6
7	6.06	3.50	6.05	3.53	6.03	3.55	6.02	3.58	7
8	6.93	4.00	6.91	4.03	6.89	4.06	6.88	4.09	8
9	7.79	4.50	7.77	4.53	7.75	4.57	7.73	4.60	9
10	8.66	5.00	8.64	5.04	8.62	5.08	8.59	5.11	10
11	9.53	5.50	9.50	5.54	9.48	5.58	9.45	5.62	11
12	10.39	6.00	10.37	6.05	10.34	6.09	10.31	6.14	12
13	11.26	6.50	11.23	6.55	11.20	6.60	11.17	6.65	13
14	12.12	7.00	12.09	7.05	12.06	7.11	12.03	7.16	14
15	12.99	7.50	12.96	7.56	12.92	7.61	12.89	7.67	15
16	13.86	8.00	13.82	8.06	13.79	8.12	13.75	8.18	16
17	14.72	8.50	14.69	8.56	14.65	8.63	14.61	8.69	17
18	15.59	9.00	15.55	9.07	15.51	9.14	15.47	9.20	18
19	16.45	9.50	16.41	9.57	16.37	9.64	16.33	9.71	19
20	17.32	10.00	17.28	10.08	17.23	10.15	17.19	10.23	20
21	18.19	10.50	18.14	10.58	18.09	10.66	18.05	10.74	21
22	19.05	11.00	19.00	11.08	18.96	11.17	18.91	11.25	22
23	19.92	11.50	19.87	11.59	19.82	11.67	19.77	11.76	23
24	20.78	12.00	20.73	12.09	20.68	12.18	20.63	12.27	24
25	21.65	12.50	21.60	12.59	21.54	12.69	21.49	12.78	25
26	22.52	13.00	22.46	13.10	22.40	13.20	22.34	13.29	26
27	23.38	13.50	23.32	13.60	23.26	13.70	23.20	13.80	27
28	24.25	14.00	24.19	14.11	24.13	14.21	24.06	14.32	28
29	25.11	14.50	25.05	14.61	24.99	14.72	24.92	14.83	29
30	25.98	15.00	25.92	15.11	25.85	15.23	25.78	15.34	30
31	26.85	15.50	26.78	15.62	26.71	15.73	26.64	15.85	31
32	27.71	16.00	27.64	16.12	27.57	16.24	27.50	16.36	32
33	28.58	16.50	28.51	16.62	28.43	16.75	28.36	16.87	33
34	29.44	17.00	29.37	17.13	29.30	17.26	29.22	17.38	34
35	30.31	17.50	30.23	17.63	30.16	17.76	30.08	17.90	35
36	31.18	18.00	31.10	18.14	31.02	18.27	30.94	18.41	36
37	32.04	18.50	31.96	18.64	31.88	18.78	31.80	18.92	37
38	32.91	19.00	32.83	19.14	32.74	19.29	32.66	19.43	38
39	33.77	19.50	33.69	19.65	33.60	19.79	33.52	19.94	39
40	34.64	20.00	34.55	20.15	34.47	20.30	34.38	20.45	40
41	35.51	20.50	35.42	20.65	35.33	20.81	35.24	20.96	41
42	36.37	21.00	36.28	21.16	36.19	21.32	36.10	21.47	42
43	37.24	21.50	37.14	21.66	37.05	21.82	36.96	21.99	43
44	38.11	22.00	38.01	22.17	37.91	22.33	37.81	22.50	44
45	38.97	22.50	38.87	22.67	38.77	22.84	38.67	23.01	45
46	39.84	23.00	39.74	23.17	39.63	23.35	39.53	23.52	46
47	40.70	23.50	40.60	23.68	40.50	23.85	40.39	24.03	47
48	41.57	24.00	41.46	24.18	41.36	24.36	41.25	24.54	48
49	42.44	24.50	42.33	24.68	42.22	24.87	42.11	25.05	49
50	43.30	25.00	43.19	25.19	43.08	25.38	42.97	25.56	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	60 Deg.		59¾ Deg.		59½ Deg.		59¼ Deg.		

Distance.	30 Deg.		30¼ Deg.		30½ Deg.		30¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	44.17	25.50	44.06	25.69	43.94	25.88	43.83	26.08	51
52	45.03	26.00	44.92	26.20	44.80	26.39	44.69	26.59	52
53	45.90	26.50	45.78	26.70	45.67	26.90	45.55	27.10	53
54	46.77	27.00	46.65	27.20	46.53	27.41	46.41	27.61	54
55	47.63	27.50	47.51	27.71	47.39	27.91	47.27	28.12	55
56	48.50	28.00	48.37	28.21	48.25	28.42	48.13	28.63	56
57	49.36	28.50	49.24	28.72	49.11	28.93	48.99	29.14	57
58	50.23	29.00	50.10	29.22	49.97	29.44	49.85	29.65	58
59	51.10	29.50	50.97	29.72	50.84	29.94	50.70	30.17	59
60	51.96	30.00	51.83	30.23	51.70	30.45	51.56	30.68	60
61	52.83	30.50	52.69	30.73	52.56	30.96	52.42	31.19	61
62	53.69	31.00	53.56	31.23	53.42	31.47	53.28	31.70	62
63	54.56	31.50	54.42	31.74	54.28	31.97	54.14	32.21	63
64	55.43	32.00	55.29	32.24	55.14	32.48	55.00	32.72	64
65	56.29	32.50	56.15	32.75	56.01	32.99	55.86	33.23	65
66	57.16	33.00	57.01	33.25	56.87	33.50	56.72	33.75	66
67	58.02	33.50	57.88	33.75	57.73	34.01	57.58	34.26	67
68	58.89	34.00	58.74	34.26	58.59	34.51	58.44	34.77	68
69	59.76	34.50	59.60	34.76	59.45	35.02	59.30	35.28	69
70	60.62	35.00	60.47	35.26	60.31	35.53	60.16	35.79	70
71	61.49	35.50	61.33	35.77	61.18	36.04	61.02	36.30	71
72	62.35	36.00	62.20	36.27	62.04	36.54	61.88	36.81	72
73	63.22	36.50	63.06	36.78	62.90	37.05	62.74	37.32	73
74	64.09	37.00	63.92	37.28	63.76	37.56	63.60	37.84	74
75	64.95	37.50	64.79	37.78	64.62	38.07	64.46	38.35	75
76	65.82	38.00	65.65	38.29	65.48	38.57	65.31	38.86	76
77	66.68	38.50	66.52	38.79	66.35	39.08	66.17	39.37	77
78	67.55	39.00	67.38	39.29	67.21	39.59	67.03	39.88	78
79	68.42	39.50	68.24	39.80	68.07	40.10	67.89	40.39	79
80	69.28	40.00	69.11	40.30	68.93	40.60	68.75	40.90	80
81	70.15	40.50	69.97	40.81	69.79	41.11	69.61	41.41	81
82	71.01	41.00	70.83	41.31	70.65	41.62	70.47	41.93	82
83	71.88	41.50	71.70	41.81	71.52	42.13	71.33	42.44	83
84	72.75	42.00	72.56	42.32	72.38	42.63	72.19	42.95	84
85	73.61	42.50	73.43	42.82	73.24	43.14	73.05	43.46	85
86	74.48	43.00	74.29	43.32	74.10	43.65	73.91	43.97	86
87	75.34	43.50	75.15	43.83	74.96	44.16	74.77	44.48	87
88	76.21	44.00	76.02	44.33	75.82	44.66	75.63	44.99	88
89	77.08	44.50	76.88	44.84	76.68	45.17	76.49	45.51	89
90	77.94	45.00	77.75	45.34	77.55	45.68	77.35	46.02	90
91	78.81	45.50	78.61	45.84	78.41	46.19	78.21	46.53	91
92	79.67	46.00	79.47	46.35	79.27	46.69	79.07	47.04	92
93	80.54	46.50	80.34	46.85	80.13	47.20	79.92	47.55	93
94	81.41	47.00	81.20	47.35	80.99	47.71	80.78	48.06	94
95	82.27	47.50	82.06	47.86	81.85	48.22	81.64	48.57	95
96	83.14	48.00	82.93	48.36	82.72	48.72	82.50	49.08	96
97	84.00	48.50	83.79	48.87	83.58	49.23	83.36	49.60	97
98	84.87	49.00	84.66	49.37	84.44	49.74	84.22	50.11	98
99	85.74	49.50	85.52	49.87	85.30	50.25	85.08	50.62	99
100	86.60	50.00	86.38	50.38	86.16	50.75	85.94	51.13	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	60 Deg.		59¾ Deg.		59½ Deg.		59¼ Deg.		

Distance.	31 Deg. Lat.	31 Deg. Dep.	31¼ Deg. Lat.	31¼ Deg. Dep.	31½ Deg. Lat.	31½ Deg. Dep.	31¾ Deg. Lat.	31¾ Deg. Dep.	Distance.
1	0.86	0.51	0.85	0.52	0.85	0.52	0.85	0.53	1
2	1.71	1.03	1.71	1.04	1.71	1.04	1.70	1.05	2
3	2.57	1.55	2.56	1.56	2.56	1.57	2.55	1.58	3
4	3.43	2.06	3.42	2.08	3.41	2.09	3.40	2.10	4
5	4.29	2.58	4.27	2.59	4.26	2.61	4.25	2.63	5
6	5.14	3.09	5.13	3.11	5.12	3.13	5.10	3.16	6
7	6.00	3.61	5.98	3.63	5.97	3.66	5.95	3.68	7
8	6.86	4.12	6.84	4.15	6.82	4.18	6.80	4.21	8
9	7.71	4.64	7.69	4.67	7.67	4.70	7.65	4.74	9
10	8.57	5.15	8.55	5.19	8.53	5.22	8.50	5.26	10
11	9.43	5.67	9.40	5.71	9.38	5.75	9.35	5.79	11
12	10.29	6.18	10.26	6.23	10.23	6.27	10.20	6.31	12
13	11.14	6.70	11.11	6.74	11.08	6.79	11.05	6.84	13
14	12.00	7.21	11.97	7.26	11.94	7.31	11.90	7.37	14
15	12.86	7.73	12.82	7.78	12.79	7.84	12.76	7.89	15
16	13.71	8.24	13.68	8.30	13.64	8.36	13.61	8.42	16
17	14.57	8.76	14.53	8.82	14.49	8.88	14.46	8.95	17
18	15.43	9.27	15.39	9.34	15.35	9.40	15.31	9.47	18
19	16.29	9.79	16.24	9.86	16.20	9.93	16.16	10.00	19
20	17.14	10.30	17.10	10.38	17.05	10.45	17.01	10.52	20
21	18.00	10.82	17.95	10.89	17.91	10.97	17.86	11.05	21
22	18.86	11.33	18.81	11.41	18.76	11.49	18.71	11.58	22
23	19.71	11.85	19.66	11.93	19.61	12.02	19.56	12.10	23
24	20.57	12.36	20.52	12.45	20.46	12.54	20.41	12.63	24
25	21.43	12.88	21.37	12.97	21.32	13.06	21.26	13.16	25
26	22.29	13.39	22.23	13.49	22.17	13.58	22.11	13.68	26
27	23.14	13.91	23.08	14.01	23.02	14.11	22.96	14.21	27
28	24.00	14.42	23.94	14.53	23.87	14.63	23.81	14.73	28
29	24.86	14.94	24.79	15.04	24.73	15.15	24.66	15.26	29
30	25.71	15.45	25.65	15.56	25.58	15.67	25.51	15.79	30
31	26.57	15.97	26.50	16.08	26.43	16.20	26.36	16.31	31
32	27.43	16.48	27.36	16.60	27.28	16.72	27.21	16.84	32
33	28.29	17.00	28.21	17.12	28.14	17.24	28.06	17.37	33
34	29.14	17.51	29.07	17.64	28.99	17.76	28.91	17.89	34
35	30.00	18.03	29.92	18.16	29.84	18.29	29.76	18.42	35
36	30.86	18.54	30.78	18.68	30.70	18.81	30.61	18.94	36
37	31.72	19.06	31.63	19.19	31.55	19.33	31.46	19.47	37
38	32.57	19.57	32.49	19.71	32.40	19.85	32.31	20.00	38
39	33.43	20.09	33.34	20.23	33.25	20.38	33.16	20.52	39
40	34.29	20.60	34.20	20.75	34.11	20.90	34.01	21.05	40
41	35.14	21.12	35.05	21.27	34.96	21.42	34.86	21.57	41
42	36.00	21.63	35.91	21.79	35.81	21.91	35.71	22.10	42
43	36.86	22.15	36.76	22.31	36.66	22.47	36.57	22.63	43
44	37.72	22.66	37.62	22.83	37.52	22.99	37.42	23.15	44
45	38.57	23.18	38.47	23.34	38.37	23.51	38.27	23.68	45
46	39.43	23.69	39.33	23.86	39.22	24.03	39.12	24.21	46
47	40.29	24.21	40.18	24.38	40.07	24.56	39.97	24.73	47
48	41.14	24.72	41.04	24.90	40.93	25.08	40.82	25.26	48
49	42.00	25.24	41.89	25.42	41.78	25.60	41.67	25.78	49
50	42.86	25.75	42.75	25.94	42.63	26.12	42.52	26.31	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	59 Deg.		58¾ Deg.		58½ Deg.		58¼ Deg.		

Distance.	31 Deg.		31¼ Deg.		31½ Deg.		31¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	43.72	26.27	43.60	26.46	43.48	26.65	43.37	26.84	51
52	44.57	26.78	44.46	26.96	44.34	27.17	44.22	27.36	52
53	45.43	27.30	45.31	27.49	45.19	27.69	45.07	27.89	53
54	46.29	27.81	46.17	28.01	46.04	28.21	45.92	28.42	54
55	47.14	28.33	47.02	28.53	46.90	28.74	46.77	28.94	55
56	48.00	28.84	47.88	29.05	47.75	29.26	47.62	29.47	56
57	48.86	29.36	48.73	29.57	48.60	29.78	48.47	29.99	57
58	49.72	29.87	49.58	30.09	49.45	30.30	49.32	30.52	58
59	50.57	30.39	50.44	30.61	50.31	30.83	50.17	31.05	59
60	51.43	30.90	51.29	31.13	51.16	31.35	51.02	31.57	60
61	52.29	31.42	52.15	31.65	52.01	31.87	51.87	32.10	61
62	53.14	31.93	53.00	32.16	52.86	32.39	52.72	32.63	62
63	54.00	32.45	53.86	32.68	53.72	32.92	53.57	33.15	63
64	54.86	32.96	54.71	33.20	54.57	33.44	54.42	33.68	64
65	55.72	33.48	55.57	33.72	55.42	33.96	55.27	34.20	65
66	56.57	33.99	56.42	34.24	56.27	34.48	56.12	34.73	66
67	57.43	34.51	57.28	34.76	57.13	35.01	56.98	35.26	67
68	58.29	35.02	58.13	35.28	57.98	35.53	57.82	35.78	68
69	59.14	35.54	58.99	35.80	58.83	36.05	58.67	36.31	69
70	60.00	36.05	59.84	36.31	59.68	36.57	59.52	36.83	70
71	60.86	36.57	60.70	36.83	60.54	37.10	60.37	37.36	71
72	61.72	37.08	61.55	37.35	61.39	37.62	61.23	37.89	72
73	62.57	37.60	62.41	37.87	62.24	38.14	62.08	38.41	73
74	63.43	38.11	63.26	38.39	63.10	38.66	62.93	38.94	74
75	64.29	38.63	64.12	38.91	63.95	39.19	63.78	39.47	75
76	65.14	39.14	64.97	39.43	64.80	39.71	64.63	39.99	76
77	66.00	39.66	65.83	39.95	65.65	40.23	65.48	40.52	77
78	66.86	40.17	66.68	40.46	66.51	40.75	66.33	41.04	78
79	67.72	40.69	67.54	40.98	67.36	41.28	67.18	41.57	79
80	68.57	41.20	68.39	41.50	68.21	41.80	58.03	42.10	80
81	69.43	41.72	69.25	42.02	69.06	42.32	68.88	42.62	81
82	70.29	42.23	70.10	42.54	69.92	42.84	69.73	43.15	82
83	71.14	42.75	70.96	43.06	70.77	43.37	70.58	43.68	83
84	72.00	43.26	71.81	43.58	71.62	43.89	71.43	44.20	84
85	72.86	43.78	72.67	44.10	72.47	44.41	72.28	44.73	85
86	73.72	44.29	73.52	44.61	73.33	44.92	73.13	45.25	86
87	74.57	44.81	74.38	45.13	74.18	45.46	73.98	45.78	87
88	75.43	45.32	75.23	45.65	75.03	45.98	74.83	46.31	88
89	76.29	45.84	76.09	46.17	75.88	46.50	75.68	46.83	89
90	77.15	46.35	76.94	46.69	76.74	47.02	76.52	47.36	90
91	78.00	46.87	77.80	47.21	77.59	47.55	77.38	47.89	91
92	78.86	47.38	78.65	47.73	78.44	48.07	78.23	48.41	92
93	79.72	47.90	79.51	48.25	79.30	48.59	79.08	48.94	93
94	80.57	48.41	80.36	48.76	80.15	49.11	79.93	49.47	94
95	81.43	48.93	81.22	49.28	81.00	49.64	80.78	49.99	95
96	82.29	49.44	82.07	49.80	81.85	50.16	81.63	50.52	96
97	83.15	49.96	82.93	50.32	82.71	50.68	82.48	51.04	97
98	84.00	50.47	83.78	50.84	83.56	51.20	83.33	51.57	98
99	84.86	50.99	84.64	51.36	84.41	51.73	84.18	52.10	99
100	85.72	51.50	85.49	51.88	85.26	52.25	85.04	52.62	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	59 Deg.		58¾ Deg.		58½ Deg.		58¼ Deg.		

Distance.	32 Deg.		32¼ Deg.		32½ Deg.		32¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.85	0.53	0.85	0.53	0.84	0.54	0.84	0.54	1
2	1.70	1.06	1.69	1.07	1.69	1.07	1.68	1.08	2
3	2.54	1.59	2.54	1.60	2.53	1.61	2.52	1.62	3
4	3.39	2.12	3.38	2.13	3.37	2.15	3.36	2.16	4
5	4.24	2.65	4.23	2.67	4.22	2.69	4.21	2.70	5
6	5.09	3.18	5.07	3.20	5.06	3.22	5.05	3.25	6
7	5.94	3.71	5.92	3.74	5.90	3.76	5.89	3.79	7
8	6.78	4.24	6.77	4.27	6.75	4.30	6.73	4.33	8
9	7.63	4.77	7.61	4.80	7.59	4.84	7.57	4.87	9
10	8.48	5.30	8.46	5.34	8.43	5.37	8.41	5.41	10
11	9.33	5.83	9.30	5.87	9.28	5.91	9.25	5.95	11
12	10.18	6.36	10.15	6.40	10.12	6.45	10.09	6.49	12
13	11.02	6.89	10.99	6.94	10.96	6.98	10.93	7.03	13
14	11.87	7.42	11.84	7.47	11.81	7.52	11.77	7.57	14
15	12.72	7.95	12.69	8.00	12.65	8.06	12.62	8.11	15
16	13.57	8.48	13.53	8.54	13.49	8.60	13.46	8.66	16
17	14.42	9.01	14.38	9.07	14.34	9.13	14.30	9.20	17
18	15.26	9.54	15.22	9.61	15.18	9.67	15.14	9.74	18
19	16.11	10.07	16.07	10.14	16.02	10.21	15.98	10.28	19
20	16.96	10.60	16.91	10.67	16.87	10.75	16.82	10.82	20
21	17.81	11.13	17.76	11.21	17.71	11.28	17.66	11.36	21
22	18.66	11.66	18.61	11.74	18.55	11.82	18.50	11.90	22
23	19.51	12.19	19.45	12.27	19.40	12.36	19.34	12.44	23
24	20.35	12.72	20.30	12.81	20.24	12.90	20.18	12.98	24
25	21.20	13.25	21.14	13.34	21.08	13.43	21.03	13.52	25
26	22.05	13.78	21.99	13.87	21.93	13.97	21.87	14.07	26
27	22.90	14.31	22.83	14.41	22.77	14.51	22.71	14.61	27
28	23.75	14.84	23.68	14.94	23.61	15.04	23.55	15.15	28
29	24.59	15.37	24.53	15.47	24.46	15.58	24.39	15.69	29
30	25.44	15.90	25.37	16.01	25.30	16.12	25.23	16.23	30
31	26.29	16.43	26.22	16.54	26.15	16.66	26.07	16.77	31
32	27.14	16.96	27.06	17.08	26.99	17.19	26.91	17.31	32
33	27.99	17.49	27.91	17.61	27.83	17.73	27.75	17.85	33
34	28.83	18.02	28.75	18.14	28.68	18.27	28.60	18.39	34
35	29.68	18.55	29.60	18.68	29.52	18.81	29.44	18.93	35
36	30.53	19.08	30.45	19.21	30.36	19.34	30.28	19.48	36
37	31.38	19.61	31.29	19.74	31.21	19.88	31.12	20.02	37
38	32.23	20.14	32.14	20.28	32.05	20.42	31.96	20.56	38
39	33.07	20.67	32.98	20.81	32.89	20.95	32.80	21.10	39
40	33.92	21.20	33.83	21.34	33.74	21.49	33.64	21.64	40
41	34.77	21.73	34.67	21.88	34.58	22.03	34.48	22.18	41
42	35.62	22.26	35.52	22.41	35.42	22.57	35.32	22.72	42
43	36.47	22.79	36.37	22.95	36.27	23.10	36.16	23.26	43
44	37.31	23.32	37.21	23.48	37.11	23.64	37.01	23.80	44
45	38.16	23.85	38.06	24.01	37.95	24.18	37.85	24.34	45
46	39.01	24.38	38.90	24.55	38.80	24.72	38.69	24.88	46
47	39.86	24.91	39.75	25.08	39.64	25.25	39.53	25.43	47
48	40.71	25.44	40.59	25.61	40.48	25.79	40.37	25.97	48
49	41.55	25.97	41.44	26.15	41.33	26.33	41.21	26.51	49
50	42.40	26.50	42.29	26.68	42.17	26.86	42.05	27.05	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	58 Deg.		57¾ Deg.		57½ Deg.		57¼ Deg.		

Distance.	32 Deg.		32¼ Deg.		32½ Deg.		32¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	43.25	27.03	43.13	27.21	43.01	27.40	42.89	27.59	51
52	44.10	27.56	43.98	27.75	43.86	27.94	43.73	28.13	52
53	44.95	28.09	44.82	28.28	44.70	28.48	44.58	28.67	53
54	45.79	28.62	45.67	28.82	45.54	29.01	45.42	29.21	54
55	46.64	29.15	46.51	29.35	46.39	29.55	46.26	29.75	55
56	47.49	29.68	47.36	29.88	47.23	30.09	47.10	30.29	56
57	48.34	30.21	48.21	30.42	48.07	30.63	47.94	30.84	57
58	49.19	30.74	49.05	30.95	48.92	31.16	48.78	31.38	58
59	50.03	31.27	49.90	31.48	49.76	31.70	49.62	31.92	59
60	50.88	31.80	50.74	32.02	50.60	32.24	50.46	32.46	60
61	51.73	32.33	51.59	32.55	51.45	32.78	51.30	33.00	61
62	52.58	32.85	52.44	33.08	52.29	33.31	52.14	33.54	62
63	53.43	33.38	53.28	33.62	53.13	33.85	52.99	34.08	63
64	54.28	33.91	54.13	34.15	53.98	34.39	53.83	34.62	64
65	55.12	34.44	54.97	34.68	54.82	34.92	54.67	35.16	65
66	55.97	34.97	55.82	35.22	55.66	35.46	55.51	35.70	66
67	56.82	35.50	56.66	35.75	56.51	36.00	56.35	36.25	67
68	57.67	36.03	57.51	36.29	57.35	36.54	57.19	36.79	68
69	58.52	36.56	58.36	36.82	58.19	37.07	58.03	37.33	69
70	59.36	37.09	59.20	37.35	59.04	37.61	58.87	37.87	70
71	60.21	37.62	60.05	37.89	59.88	38.15	59.71	38.41	71
72	61.06	38.15	60.89	38.42	60.72	38.69	60.55	38.95	72
73	61.91	38.68	61.74	38.95	61.57	39.22	61.40	39.49	73
74	62.76	39.21	62.58	39.49	62.41	39.76	62.24	40.03	74
75	63.60	39.74	63.43	40.02	63.25	40.30	63.08	40.57	75
76	64.45	40.27	64.28	40.55	64.10	40.83	63.92	41.11	76
77	65.30	40.80	65.12	41.09	64.94	41.37	64.76	41.65	77
78	66.15	41.33	65.97	41.62	65.78	41.91	65.60	42.20	78
79	67.00	41.86	66.81	42.16	66.63	42.45	66.44	42.74	79
80	67.84	42.39	67.66	42.69	67.47	42.98	67.28	43.28	80
81	68.69	42.92	68.50	43.22	68.31	43.52	68.12	43.82	81
82	69.54	43.45	69.35	43.76	69.16	44.06	68.97	44.36	82
83	70.39	43.98	70.20	44.29	70.00	44.60	69.81	44.90	83
84	71.24	44.51	71.04	44.82	70.84	45.13	70.65	45.44	84
85	72.08	45.04	71.89	45.36	71.69	45.67	71.49	45.98	85
86	72.93	45.57	72.73	45.89	72.53	46.21	72.33	46.52	86
87	73.78	46.10	7[illegible].58	46.42	73.38	46.75	73.17	47.06	87
88	74.63	46.63	74.42	46.96	74.22	47.28	74.01	47.61	88
89	75.48	47.16	75.27	47.49	75.06	47.82	74.85	48.15	89
90	76.32	47.69	76.12	48.03	75.91	48.36	75.69	48.69	90
91	77.17	48.22	76.96	48.56	76.75	48.89	76.53	49.23	91
92	78.02	48.75	77.81	49.09	77.59	49.43	77.38	49.77	92
93	78.87	49.28	78.65	49.63	78.44	49.97	78.22	50.31	93
94	79.72	49.81	79.50	50.16	79.28	50.51	79.06	50.85	94
95	80.56	50.34	80.34	50.69	80.12	51.04	79.90	51.39	95
96	81.41	50.87	81.19	51.23	80.97	51.58	80.74	51.93	96
97	82.26	51.40	82.04	51.76	81.81	52.12	81.58	52.47	97
98	83.11	51.93	82.88	52.29	82.65	52.66	82.42	53.02	98
99	83.96	52.46	83.73	52.83	83.50	53.19	83.26	53.56	99
100	84.80	52.99	84.57	53.36	84.34	53.73	84.10	54.10	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	58 Deg.		57¾ Deg.		57½ Deg.		57¼ Deg.		

Distance.	33 Deg.		33¼ Deg.		33½ Deg.		33¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.84	0.54	0.84	0.55	0.83	0.55	0.83	0.56	1
2	1.68	1.09	1.67	1.10	1.67	1.10	1.66	1.11	2
3	2.52	1.63	2.51	1.64	2.50	1.66	2.49	1.67	3
4	3.35	2.18	3.35	2.19	3.34	2.21	3.33	2.22	4
5	4.19	2.72	4.18	2.74	4.17	2.76	4.16	2.78	5
6	5.03	3.27	5.02	3.29	5.00	3.31	4.99	3.33	6
7	5.87	3.81	5.85	3.84	5.84	3.86	5.82	3.89	7
8	6.71	4.36	6.69	4.39	6.67	4.42	6.65	4.44	8
9	7.55	4.90	7.53	4.93	7.50	4.97	7.48	5.00	9
10	8.39	5.45	8.36	5.48	8.34	5.52	8.31	5.56	10
11	9.23	5.99	9.20	6.03	9.17	6.07	9.15	6.11	11
12	10.06	6.54	10.04	6.58	10.01	6.62	9.98	6.67	12
13	10.90	7.08	10.87	7.13	10.84	7.18	10.81	7.22	13
14	11.74	7.62	11.71	7.68	11.67	7.73	11.64	7.78	14
15	12.58	8.17	12.54	8.22	12.51	8.28	12.47	8.33	15
16	13.42	8.71	13.38	8.77	13.34	8.83	13.30	8.89	16
17	14.26	9.26	14.22	9.32	14.18	9.38	14.13	9.44	17
18	15.10	9.80	15.05	9.87	15.01	9.93	14.97	10.00	18
19	15.93	10.35	15.89	10.42	15.84	10.49	15.80	10.56	19
20	16.77	10.89	16.73	10.97	16.68	11.04	16.63	11.11	20
21	17.61	11.44	17.56	11.51	17.51	11.59	17.46	11.67	21
22	18.45	11.98	18.40	12.06	18.35	12.14	18.29	12.22	22
23	19.29	12.53	19.23	12.61	19.18	12.69	19.12	12.78	23
24	20.13	13.07	20.07	13.16	20.01	13.25	19.96	13.33	24
25	20.97	13.62	20.91	13.71	20.85	13.80	20.79	13.89	25
26	21.81	14.16	21.74	14.25	21.68	14.35	21.62	14.44	26
27	22.64	14.71	22.58	14.80	22.51	14.90	22.45	15.00	27
28	23.48	15.25	23.42	15.35	23.35	15.45	23.28	15.56	28
29	24.32	15.79	24.25	15.90	24.18	16.01	24.11	16.11	29
30	25.16	16.34	25.09	16.45	25.02	16.56	24.94	16.67	30
31	26.00	16.88	25.92	17.00	25.85	17.11	25.78	17.22	31
32	26.84	17.43	26.76	17.55	26.68	17.66	26.61	17.78	32
33	27.68	17.97	27.60	18.09	27.52	18.21	27.44	18.33	33
34	28.51	18.52	28.43	18.64	28.35	18.77	28.27	18.89	34
35	29.35	19.06	29.27	19.19	29.19	19.32	29.10	19.44	35
36	30.19	19.61	30.11	19.74	30.02	19.87	29.93	20.00	36
37	31.03	20.15	30.94	20.29	30.85	20.42	30.76	20.56	37
38	31.87	20.70	31.78	20.84	31.69	20.97	31.60	21.11	38
39	32 71	21.24	32.62	21.38	32.52	21.53	32.43	21.67	39
40	33.55	21.79	33.45	21.93	33.36	22.08	33.26	22.22	40
41	34.39	22.33	34.29	22.48	34.19	22.63	34.09	22.78	41
42	35.22	22.87	35.12	23.03	35.02	23.18	34.92	23.33	42
43	36.06	23.42	35.96	23.58	35.86	23.73	35.75	23.89	43
44	36.90	23.96	36.80	24.12	36.69	24.29	36.58	24.45	44
45	37.74	24.51	37.63	24.67	37.52	24.84	37.42	25.00	45
46	38.58	25.05	38.47	25.22	38.36	25.39	38.25	25.56	46
47	39.42	25.60	39.31	25.77	39.19	25.94	39.08	26.11	47
48	40.26	26.14	40.14	26.32	40.03	26.49	39.91	26.67	48
49	41.09	26.69	40.98	26.87	40.86	27.04	40.74	27.22	49
50	41.93	27.23	41.81	27.41	41.69	27.60	41.57	27.78	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	57 Deg.		56¾ Deg.		56½ Deg.		56¼ Deg.		

Distance.	33 Deg.		33¼ Deg.		33½ Deg.		33¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	
51	42.77	27.78	42.65	27.93	42.53	28.15	42.40	28.33	51
52	43.61	28.32	43.49	28.51	43.36	28.70	43.24	28.89	52
53	44.45	28.87	44.32	29.06	44.20	29.25	44.07	29.45	53
54	45.29	29.41	45.16	29.61	45.03	29.80	44.90	30.00	54
55	46.13	29.96	46.00	30.16	45.86	30.36	45.73	30.56	55
56	46.97	30.50	46.83	30.70	46.70	30.91	46.56	31.11	56
57	47.80	31.04	47.67	31.25	47.53	31.46	47.39	31.67	57
58	48.64	31.59	48.50	31.80	48.37	32.01	48.23	32.22	58
59	49.48	32.13	49.34	32.35	49.20	32.56	49.06	32.78	59
60	50.32	32.68	50.18	32.90	50.03	33.12	49.89	33.33	60
61	51.16	33.22	51.01	33.45	50.87	33.67	50.72	33.89	61
62	52.00	33.77	51.85	33.99	51.70	34.22	51.55	34.45	62
63	52.84	34.31	52.69	34.54	52.53	34.77	52.38	35.00	63
64	53.67	34.86	53.52	35.09	53.37	35.32	53.21	35.56	64
65	54.51	35.40	54.36	35.64	54.20	35.88	54.05	36.11	65
66	55.35	35.95	55.19	36.19	55.04	36.43	54.88	36.67	66
67	56.19	36.49	56.03	36.74	55.87	36.98	55.71	37.22	67
68	57.03	37.04	56.87	37.28	56.70	37.53	56.54	37.78	68
69	57.87	37.58	57.70	37.83	57.54	38.08	57.37	38.33	69
70	58.71	38.12	58.54	38.38	58.37	38.64	58.20	38.89	70
71	59.55	38.67	59.38	38.93	59.21	39.19	59.03	39.45	71
72	60.38	39.21	60.21	39.48	60.04	39.74	59.87	40.00	72
73	61.22	39.76	61.05	40.03	60.87	40.29	60.70	40.56	73
74	62.06	40.30	61.89	40.57	61.71	40.84	61.53	41.11	74
75	62.90	40.85	62.72	41.12	62.54	41.40	62.36	41.67	75
76	63.74	41.39	63.56	41.67	63.38	41.95	63.19	42.22	76
77	64.58	41.94	64.39	42.22	64.21	42.50	64.02	42.78	77
78	65.42	42.48	65.23	42.77	65.04	43.05	64.85	43.33	78
79	66.25	43.03	66.07	43.32	65.88	43.60	65.69	43.89	79
80	67.09	43.57	66.90	43.86	66.71	44.16	66.52	44.45	80
81	67.93	44.12	67.74	44.41	67.54	44.71	67.35	45.00	81
82	68.77	44.66	68.58	44.96	68.38	45.26	68.18	45.56	82
83	69.61	45.20	69.41	45.51	69.21	45.81	69.01	46.11	83
84	70.45	45.75	70.25	46.06	70.05	46.36	69.84	46.67	84
85	71.29	46.29	71.08	46.60	70.88	46.91	70.67	47.22	85
86	72.13	46.84	71.92	47.15	71.71	47.47	71.51	47.78	86
87	72.96	47.38	72.76	47.70	72.55	48.02	72.34	48.33	87
88	73.80	47.93	73.59	48.25	73.38	48.57	73.17	48.89	88
89	74.64	48.47	74.43	48.80	74.22	49.12	74.00	49.45	89
90	75.48	49.02	75.27	49.35	75.05	49.67	74.83	50.00	90
91	76.32	49.56	76.10	49.89	75.88	50.23	75.66	50.56	91
92	77.16	50.11	76.94	50.44	76.72	50.78	76.50	51.11	92
93	78.00	50.65	77.77	50.99	77.55	51.33	77.33	51.67	93
94	78.83	51.20	78.61	51.54	78.39	51.88	78.16	52.22	94
95	79.67	51.74	79.45	52.09	79.22	52.43	78.99	52.78	95
96	80.51	52.29	80.28	52.64	80.05	52.99	79.82	53.33	96
97	81.35	52.83	81.12	53.18	80.89	53.54	80.65	53.89	97
98	82.19	53.37	81.96	53.73	81.72	54.09	81.48	54.45	98
99	83.03	53.92	82.79	54.28	82.55	54.64	82.32	55.00	99
100	83.87	54.46	83.63	54.83	83.39	55.19	83.15	55.56	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	57 Deg.		56¾ Deg.		56½ Deg.		56¼ Deg.		

Distance.	34 Deg. Lat.	34 Deg. Dep.	34¼ Deg. Lat.	34¼ Deg. Dep.	34½ Deg. Lat.	34½ Deg. Dep.	34¾ Deg. Lat.	34¾ Deg. Dep.	Distance.
1	0.83	0.56	0.83	0.56	0.82	0.57	0.82	0.57	1
2	1.66	1.12	1.65	1.13	1.65	1.13	1.64	1.14	2
3	2.49	1.68	2.48	1.69	2.47	1.70	2.46	1.71	3
4	3.32	2.24	3.31	2.25	3.30	2.27	3.29	2.28	4
5	4.15	2.80	4.13	2.81	4.12	2.83	4.11	2.85	5
6	4.97	3.36	4.96	3.38	4.94	3.40	4.93	3.42	6
7	5.80	3.91	5.79	3.94	5.77	3.96	5.75	3.99	7
8	6.63	4.47	6.61	4.50	6.59	4.53	6.57	4.56	8
9	7.46	5.03	7.44	5.07	7.42	5.10	7.39	5.13	9
10	8.29	5.59	8.27	5.63	8.24	5.66	8.22	5.70	10
11	9.12	6.15	9.09	6.19	9.07	6.23	9.04	6.27	11
12	9.95	6.71	9.92	6.75	9.89	6.80	9.86	6.84	12
13	10.78	7.27	10.75	7.32	10.71	7.36	10.68	7.41	13
14	11.61	7.83	11.57	7.88	11.54	7.93	11.50	7.98	14
15	12.44	8.39	12.40	8.44	12.36	8.50	12.32	8.55	15
16	13.20	8.95	13.23	9.00	13.19	9.06	13.15	9.12	16
17	14.09	9.51	14.05	9.57	14.01	9.63	13.97	9.69	17
18	14.92	10.07	14.88	10.13	14.83	10.20	14.79	10.26	18
19	15.75	10.62	15.71	10.69	15.66	10.76	15.61	10.83	19
20	16.58	11.18	16.53	11.26	16.48	11.33	16.43	11.40	20
21	17.41	11.74	17.36	11.82	17.31	11.89	17.25	11.97	21
22	18.24	12.30	18.18	12.38	18.13	12.46	18.08	12.54	22
23	19.07	12.86	19.01	12.94	18.95	13.03	18.90	13.11	23
24	19.90	13.42	19.84	13.51	19.78	13.59	19.72	13.68	24
25	20.73	13.98	20.66	14.07	20.60	14.16	20.54	14.25	25
26	21.55	14.54	21.49	14.63	21.43	14.73	21.36	14.82	26
27	22.38	15.10	22.32	15.20	22.25	15.29	22.18	15.39	27
28	23.21	15.66	23.14	15.76	23.08	15.86	23.01	15.96	28
29	24.04	16.22	23.97	16.32	23.90	16.43	23.83	16.53	29
30	24.87	16.78	24.80	16.88	24.72	16.99	24.65	17.10	30
31	25.70	17.33	25.62	17.45	25.55	17.56	25.47	17.67	31
32	26.53	17.89	26.45	18.01	26.37	18.12	26.29	18.24	32
33	27.36	18.45	27.28	18.57	27.20	18.69	27.11	18.81	33
34	28.19	19.01	28.10	19.14	28.02	19.26	27.94	19.38	34
35	29.02	19.57	28.93	19.70	28.84	19.82	28.76	19.95	35
36	29.85	20.13	29.76	20.26	29.67	20.39	29.58	20.52	36
37	30.67	20.69	30.58	20.82	30.49	20.96	30.40	21.09	37
38	31.50	21.25	31.41	21.39	31.32	21.52	31.22	21.66	38
39	32.33	21.81	32.24	21.95	32.14	22.09	32.04	22.23	39
40	33.16	22.37	33.06	22.51	32.97	22.66	32.87	22.80	40
41	33.99	22.93	33.89	23.07	33.79	23.22	33.69	23.37	41
42	34.82	23.49	34.72	23.64	34.61	23.79	34.51	23.94	42
43	35.65	24.05	35.54	24.20	35.44	24.36	35.33	24.51	43
44	36.48	24.60	36.37	24.76	36.26	24.92	36.15	25.08	44
45	37.31	25.16	37.20	25.33	37.09	25.49	36.97	25.65	45
46	38.14	25.72	38.02	25.89	37.91	26.05	37.80	26.22	46
47	38.96	26.28	38.85	26.45	38.73	26.62	38.62	26.79	47
48	39.79	26.84	39.68	27.01	39.56	27.19	39.44	27.36	48
49	40.62	27.40	40.50	27.58	40.38	27.75	40.26	27.93	49
50	41.45	27.96	41.33	28.14	41.21	28.32	41.08	28.50	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	56 Deg.		55¾ Deg.		55½ Deg.		55¼ Deg.		

Distance.	34 Deg.		34¼ Deg.		34½ Deg.		34¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	42.28	28.52	42.16	28.70	42.03	28.89	41.90	29.07	51
52	43.11	29.08	42.98	29.27	42.85	29.45	42.73	29.64	52
53	43.94	29.64	43.81	29.83	43.68	30.02	43.55	30.21	53
54	44.77	30.20	44.64	30.39	44.50	30.59	44.37	30.78	54
55	45.60	30.76	45.46	30.95	45.33	31.15	45.19	31.35	55
56	46.43	31.31	46.29	31.52	46.15	31.72	46.01	31.92	56
57	47.26	31.87	47.12	32.08	46.98	32.29	46.83	32.49	57
58	48.08	32.43	47.94	32.64	47.80	32.85	47.66	33.06	58
59	48.91	32.99	48.77	33.21	48.62	33.42	48.48	33.63	59
60	49.74	33.55	49.60	33.77	49.45	33.98	49.30	34.20	60
61	50.57	34.11	50.42	34.33	50.27	34.55	50.12	34.77	61
62	51.40	34.67	51.25	34.89	51.10	35.12	50.94	35.34	62
63	52.23	35.23	52.08	35.46	51.92	35.68	51.76	35.91	63
64	53.06	35.79	52.90	36.02	52.74	36.25	52.59	36.48	64
65	53.89	36.35	53.73	36.58	53.57	36.82	53.41	37.05	65
66	54.72	36.91	54.55	37.15	54.39	37.38	54.23	37.62	66
67	55.55	37.46	55.38	37.71	55.22	37.95	55.05	38.19	67
68	56.37	38.03	56.21	38.27	56.04	38.52	55.87	38.76	68
69	57.20	38.58	57.03	38.83	56.86	39.08	56.69	39.33	69
70	58.03	39.14	57.86	39.40	57.69	39.65	57.52	39.90	70
71	58.86	39.70	58.69	39.96	58.51	40.21	58.34	40.47	71
72	59.69	40.26	59.51	40.52	59.34	40.78	59.16	41.04	72
73	60.52	40.82	60.34	41.08	60.16	41.35	59.98	41.61	73
74	61.35	41.38	61.17	41.65	60.99	41.91	60.80	42.18	74
75	62.18	41.94	61.99	42.21	61.81	42.48	61.62	42.75	75
76	63.01	42.50	62.82	42.77	62.63	43.05	62.45	43.32	76
77	63.84	43.06	63.65	43.34	63.46	43.61	63.27	43.89	77
78	64.66	43.62	64.47	43.90	64.28	44.18	64.09	44.46	78
79	65.49	44.18	65.30	44.46	65.11	44.75	64.91	45.03	79
80	66.32	44.74	66.13	45.02	65.93	45.31	65.73	45.60	80
81	67.15	45.29	66.95	45.59	66.75	45.88	66.55	46.17	81
82	67.98	45.85	67.78	46.15	67.58	46.45	67.37	46.74	82
83	68.81	46.41	68.61	46.71	68.40	47.01	68.20	47.31	83
84	69.64	46.97	69.43	47.28	69.23	47.58	69.02	47.88	84
85	70.47	47.53	70.26	47.84	70.05	48.14	69.84	48.45	85
86	71.30	48.09	71.09	48.40	70.87	48.71	70.66	49.02	86
87	72.13	48.65	71.91	48.96	71.70	49.28	71.48	49.59	87
88	72.96	49.21	72.74	49.53	72.52	49.84	72.30	50.16	88
89	73.78	49.77	73.57	50.09	73.35	50.41	73.13	50.73	89
90	74.61	50.33	74.39	50.65	74.17	50.98	73.95	51.30	90
91	75.44	50.89	75.22	51.22	75.00	51.54	74.77	51.87	91
92	76.27	51.45	76.05	51.78	75.82	52.11	75.59	52.44	92
93	77.10	52.00	76.87	52.34	76.64	52.68	76.41	53.01	93
94	77.93	52.56	77.70	52.90	77.47	53.24	77.23	53.58	94
95	78.76	53.12	78.53	53.47	78.29	53.81	78.06	54.15	95
96	79.59	53.68	79.35	54.03	79.12	54.37	78.88	54.72	96
97	80.42	54.24	80.18	54.59	79.94	54.94	79.70	55.29	97
98	81.25	54.80	81.01	55.15	80.76	55.51	80.52	55.86	98
99	82.07	55.36	81.83	55.72	81.59	56.07	81.34	56.43	99
100	82.90	55.92	82.66	56.28	82.41	56.64	82.16	57.00	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	56 Deg.		55¾ Deg.		55½ Deg.		55¼ Deg.		

Distance.	35 Deg.		35¼ Deg.		35½ Deg.		35¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.82	0.57	0.82	0.58	0.81	0.58	0.81	0.58	1
2	1.64	1.15	1.63	1.15	1.63	1.16	1.62	1.17	2
3	2.46	1.72	2.45	1.73	2.44	1.74	2.43	1.75	3
4	3.28	2.29	3.27	2.31	3.26	2.32	3.25	2.34	4
5	4.10	2.87	4.08	2.89	4.07	2.90	4.06	2.92	5
6	4.91	3.44	4.90	3.46	4.88	3.48	4.87	3.51	6
7	5.73	4.01	5.72	4.04	5.70	4.06	5.68	4.09	7
8	6.55	4.59	6.53	4.62	6.51	4.65	6.49	4.67	8
9	7.37	5.16	7.35	5.19	7.33	5.23	7.30	5.26	9
10	8.19	5.74	8.17	5.77	8.14	5.81	8.12	5.84	10
11	9.01	6.31	8.98	6.35	8.96	6.39	8.93	6.43	11
12	9.83	6.88	9.80	6.93	9.77	6.97	9.74	7.01	12
13	10.65	7.46	10.62	7.50	10.58	7.55	10.55	7.60	13
14	11.47	8.03	11.43	8.08	11.40	8.13	11.36	8.18	14
15	12.29	8.60	12.25	8.66	12.21	8.71	12.17	8.76	15
16	13.11	9.18	13.07	9.23	13.03	9.29	12.99	9.35	16
17	13.93	9.75	13.88	9.81	13.84	9.87	13.80	9.93	17
18	14.74	10.32	14.70	10.39	14.65	10.45	14.61	10.52	18
19	15.56	10.90	15.52	10.97	15.47	11.03	15.42	11.10	19
20	16.38	11.47	16.33	11.54	16.28	11.61	16.23	11.68	20
21	17.20	12.05	17.15	12.12	17.10	12.19	17.04	12.27	21
22	18.02	12.62	17.97	12.70	17.91	12.78	17.85	12.85	22
23	18.84	13.19	18.78	13.27	18.72	13.36	18.67	13.44	23
24	19.66	13.77	19.60	13.85	19.54	13.94	19.48	14.02	24
25	20.48	14.34	20.42	14.43	20.35	14.52	20.29	14.61	25
26	21.30	14.91	21.23	15.01	21.17	15.10	21.10	15.19	26
27	22.12	15.49	22.05	15.58	21.98	15.68	21.91	15.77	27
28	22.94	16.06	22.87	16.15	22.80	16.26	22.72	16.36	28
29	23.76	16.63	23.68	16.74	23.61	16.84	23.54	16.94	29
30	24.57	17.21	24.50	17.31	24.42	17.42	24.35	17.53	30
31	25.39	17.78	25.32	17.89	25.24	18.00	25.16	18.11	31
32	26.21	18.35	26.13	18.47	26.05	18.58	25.97	18.70	32
33	27.03	18.93	26.95	19.05	26.87	19.16	26.78	19.28	33
34	27.85	19.50	27.77	19.62	27.68	19.74	27.59	19.86	34
35	28.67	20.08	28.58	20.20	28.49	20.32	28.41	20.45	35
36	29.49	20.65	29.40	20.78	29.31	20.91	29.22	21.03	36
37	30.31	21.22	30.22	21.35	30.12	21.49	30.03	21.62	37
38	31.13	21.80	31.03	21.93	30.94	22.07	30.84	22.20	38
39	31.95	22.37	31.85	22.51	31.75	22.65	31.65	22.79	39
40	32.77	22.94	32.67	23.09	32.56	23.23	32.46	23.37	40
41	33.59	23.52	33.48	23.66	33.38	23.81	33.27	23.95	41
42	34.40	24.09	34.30	24.24	34.19	24.39	34.09	24.54	42
43	35.22	24.66	35.12	24.82	35.01	24.97	34.90	25.12	43
44	36.04	25.24	35.93	25.39	35.82	25.55	35.71	25.71	44
45	36.86	25.81	36.75	25.97	36.64	26.13	36.52	26.29	45
46	37.68	26.38	37.57	26.55	37.45	26.71	37.33	26.88	46
47	38.50	26.96	38.38	27.13	38.26	27.29	38.14	27.46	47
48	39.32	27.53	39.20	27.70	39.08	27.87	38.96	28.04	48
49	40.14	28.11	40.02	28.28	39.89	28.45	39.77	28.63	49
50	40.96	28.68	40.83	28.86	40.71	29.04	40.58	29.21	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	55 Deg.		54¾ Deg.		54½ Deg.		54¼ Deg.		

Distance.	35 Deg.		35¼ Deg.		35½ Deg.		35¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	41.78	29.25	41.65	29.43	41.52	29.62	41.39	29.80	51
52	42.60	29.83	42.47	30.01	42.33	30.20	42.20	30.38	52
53	43.42	30.40	43.28	30.59	43.15	30.78	43.01	30.97	53
54	44.23	30.97	44.10	31.17	43.96	31.36	43.82	31.55	54
55	45.05	31.55	44.92	31.74	44.78	31.94	44.64	32.13	55
56	45.87	32.12	45.73	32.32	45.59	32.52	45.45	32.72	56
57	46.69	32.69	46.55	32.90	46.40	33.10	46.26	33.30	57
58	47.51	33.27	47.37	33.47	47.22	33.68	47.07	33.89	58
59	48.33	83.84	48.18	34.05	48.03	34.26	47.88	34.47	59
60	49.15	34.41	49.00	34.63	48.85	34.84	48.69	35.05	60
61	49.97	34.99	49.82	35.21	49.66	35.42	49.51	35.64	61
62	50.79	35.56	50.63	35.78	50.48	36.00	50.32	36.22	62
63	51.61	36.14	51.45	36.36	51.29	36.58	51.13	36.81	63
64	52.43	36.71	52.27	36.94	52.10	37.16	51.94	37.39	64
65	53.24	37.28	53.08	37.51	52.92	37.75	52.75	37.98	65
66	54.06	37.86	53.90	38.09	53.73	38.33	53.56	38.56	66
67	54.88	38.43	54.71	38.67	54.55	38.91	54.38	39.14	67
68	55.70	39.00	55.53	39.25	55.36	39.49	55.19	39.73	68
69	56.52	39.58	56.35	39.82	56.17	40.07	56.00	40.31	69
70	57.34	40.15	57.16	49 40	56.99	40.65	56.81	40.90	70
71	58.16	40.72	57.98	40.98	57.80	41.23	57.62	41.48	71
72	58.98	41.30	58.80	41.55	58.62	41.81	58.43	42.07	72
73	59.80	41.87	59.61	42.13	59.43	42.39	59.24	42.65	73
74	60.62	42.44	60.43	42.71	60.24	42.97	60.06	43.23	74
75	61.44	43.02	61.25	43.29	61.06	43.55	60.87	43.82	75
76	62.26	43.59	62.06	43.86	61.87	44.13	61.68	44.40	76
77	63.07	44.17	62.88	44.44	62.69	44.71	62.49	44.99	77
78	63.89	44.74	63.70	45.02	63.50	45.29	63.30	45.57	78
79	64.71	45.31	64.51	45.59	64.32	45.88	64.11	46.16	79
80	65.53	45.89	65.33	46.17	65.13	46.46	64.93	46.74	80
81	66.35	46.46	66.15	46.75	65.94	47.04	65.74	47.32	81
82	67.17	47.03	66.96	47.33	66.76	47.62	66.55	47.91	82
83	67.99	47.61	67.78	47.90	67.57	48.20	67.36	48.49	83
84	68.81	48.18	68.60	48.48	68.39	48.78	68.17	49.08	84
85	69.63	48.75	69.41	49.06	69.20	49.36	68.98	49.66	85
86	70.45	49.33	70.23	49.63	70.01	49.94	69.80	50.25	86
87	71.27	49.90	71.05	50.21	70.83	50.52	70.61	50.83	87
88	72.09	50 47	71.86	50.79	71.64	51.10	71.42	51.41	88
89	72.90	51.05	72.68	51.37	72.46	51.68	72.23	52.00	89
90	73.72	51.62	73.50	51.94	73.27	52.26	73.04	52.58	90
91	74.54	52.20	74.31	52.52	74.08	52.84	73.85	53.17	91
92	75.36	52.77	75.13	53.10	74.90	53.42	74.66	53.75	92
93	76.18	53.34	75.95	53.67	75.71	54.01	75.48	54.34	93
94	77.00	53.92	76.76	54.25	76.53	54.59	76.29	54.92	94
95	77.82	54.49	77.58	54.83	77.34	55.17	77.10	55.50	95
96	78.64	55.06	78.40	55.41	78.16	55.75	77.91	56.09	96
97	79.46	55.64	79.21	55.98	78 97	56.33	78.72	56.67	97
98	80.28	56.21	80.03	56.56	79.78	56.91	79.53	57.26	98
99	81.10	56.78	80.85	57.14	80.60	57.49	80.35	57.84	99
100	81.92	57.36	81.66	57.71	81.41	58.07	81.16	58.42	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	55 Deg.		54¾ Deg.		54½ Deg.		54¼ Deg.		

Distance.	36 Deg.		36¼ Deg.		36½ Deg.		36¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.81	0.59	0.81	0.59	0.80	0.59	0.80	0.60	1
2	1.62	1.18	1.61	1.18	1.61	1.19	1.60	1.20	2
3	2.43	1.76	2.42	1.77	2.41	1.78	2.40	1.79	3
4	3.24	2.35	3.23	2.37	3.22	2.38	3.20	2.39	4
5	4.05	2.94	4.03	2.96	4.02	2.97	4.01	2.99	5
6	4.85	3.53	4.84	3.55	4.82	3.57	4.81	3.59	6
7	5.66	4.11	5.65	4.14	5.63	4.16	5.61	4.19	7
8	6.47	4.70	6.45	4.73	6.43	4.76	6.41	4.79	8
9	7.28	5.29	7.26	5.32	7.23	5.35	7.21	5.38	9
10	8.09	5.88	8.06	5.91	8.04	5.95	8.01	5.98	10
11	8.90	6.47	8.87	6.50	8.84	6.54	8.81	6.58	11
12	9.71	7.05	9.68	7.10	9.65	7.14	9.61	7.18	12
13	10.52	7.64	10.48	7.69	10.45	7.73	10.42	7.78	13
14	11.33	8.23	11.29	8.28	11.25	8.33	11.22	8.38	14
15	12.14	8.82	12.10	8.87	12.06	8.92	12.02	8.97	15
16	12.94	9.40	12.90	9.46	12.86	9.52	12.82	9.57	16
17	13.75	9.99	13.71	10.05	13.67	10.11	13.62	10.17	17
18	14.56	10.58	14.52	10.64	14.47	10.71	14.42	10.77	18
19	15.37	11.17	15.32	11.23	15.27	11.30	15.22	11.37	19
20	16.18	11.76	16.13	11.83	16.08	11.90	16.03	11.97	20
21	16.99	12.34	16.94	12.42	16.88	12.49	16.83	12.56	21
22	17.80	12.93	17.74	13.01	17.68	13.09	17.63	13.16	22
23	18.61	13.52	18.55	13.60	18.49	13.68	18.43	13.76	23
24	19.42	14.11	19.35	14.19	19.29	14.28	19.23	14.36	24
25	20.23	14.69	20.16	14.78	20.10	14.87	20.03	14.96	25
26	21.03	15.28	20.97	15.37	20.90	15.47	20.83	15.56	26
27	21.84	15.87	21.77	15.97	21.70	16.06	21.63	16.15	27
28	22.65	16.46	22.58	16.56	22.51	16.65	22.44	16.75	28
29	23.46	17.05	23.39	17.15	23.31	17.25	23.24	17.35	29
30	24.27	17.63	24.19	17.74	24.12	17.84	24.04	17.95	30
31	25.08	18.22	25.00	18.33	24.92	18.44	24.84	18.55	31
32	25.89	18.81	25.81	18.92	25.72	19.03	25.64	19.15	32
33	26.70	19.40	26.61	19.51	26.53	19.63	26.44	19.74	33
34	27.51	19.98	27.42	20.10	27.33	20.22	27.24	20.34	34
35	28.32	20.57	28.23	20.70	28.13	20.82	28.04	20.94	35
36	29.12	21.16	29.03	21.29	28.94	21.41	28.85	21.54	36
37	29.93	21.75	29.84	21.88	29.74	22.01	29.65	22.14	37
38	30.74	22.34	30.64	22.47	30.55	22.60	30.45	22.74	38
39	31.55	22.92	31.45	23.06	31.35	23.20	31.25	23.33	39
40	32.36	23.51	32.26	23.65	32.15	23.79	32.05	23.93	40
41	33.17	24.10	33.06	24.24	32.96	24.39	32.85	24.53	41
42	33.98	24.69	33.87	24.83	33.76	24.98	33.65	25.13	42
43	34.79	25.27	34.68	25.43	34.57	25.58	34.45	25.73	43
44	35.60	25.86	35.48	26.02	35.37	26.17	35.26	26.33	44
45	36.41	26.45	36.29	26.61	36.17	26.77	36.06	26.92	45
46	37.21	27.04	37.10	27.20	36.98	27.36	36.86	27.52	46
47	38.02	27.63	37.90	27.79	37.78	27.96	37.66	28.12	47
48	38.83	28.21	38.71	28.38	38.59	28.55	38.46	28.72	48
49	39.64	28.80	39.52	28.97	39.30	29.15	39.26	29.32	49
50	40.45	29.39	40.32	29.57	40.19	29.74	40.06	29.92	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	54 Deg.		53¾ Deg.		53½ Deg.		53¼ Deg.		

Distance.	36 Deg.		36¼ Deg.		36½ Deg.		36¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	41.26	29.98	41.13	30.16	41.00	30.34	40.86	30.51	51
52	42.07	30.56	41.94	30.75	41.80	30.93	41.67	31.11	52
53	42.88	31.15	42.74	31.34	42.60	31.53	42.47	31.71	53
54	43.69	31.74	43.55	31.93	43.41	32.12	43.27	32.31	54
55	44.50	32.33	44.35	32.52	44.21	32.72	44.07	32.91	55
56	45.30	32.92	45.16	33.11	45.02	33.31	44.87	33.51	56
57	46.11	33.50	45.97	33.70	45.82	33.90	45.67	34.10	57
58	46.92	34.09	46.77	34.30	46.62	34.50	46.47	34.70	58
59	47.73	34.68	47.58	34.89	47.43	35 09	47.27	35.30	59
60	48.54	35.27	48.39	35.48	48.23	35.69	48.08	35.90	60
61	49.35	35.85	49.19	36.07	49.04	36.28	48.88	36.50	61
62	50.16	36.44	50.00	36.66	49.84	36.88	49.68	37.10	62
63	50.97	37.03	50.81	37.25	50.64	37.47	50.48	37.69	63
64	51.78	37.62	51.61	37.84	51.45	38.07	51.28	38.29	64
65	52.59	38.21	52.42	38.44	52.25	38.66	52.08	38.89	65
66	53.40	38.79	53.23	39.03	53.05	39.26	52.88	39.49	66
67	54.20	39.38	54.03	39.62	53.86	39.85	53.68	40.09	67
68	55.01	39.97	54.84	40.21	54.66	40.45	54.49	40.69	68
69	55.82	40.56	55.64	40.80	55.47	41.04	55.29	41.28	69
70	56.63	41.14	56.45	41.39	56.27	41.64	56.09	41.88	70
71	57.44	41.73	57.26	41.98	57.07	42.23	56.89	42.48	71
72	58.25	42.32	58.06	42.57	57.88	42.83	57.69	43.08	72
73	59.06	42.91	58.87	43.17	58.68	43.42	58.49	43.68	73
74	59.87	43.50	59.68	43.76	59.49	44.02	59.29	44.28	74
75	60.68	44.08	60.48	44.35	60.29	44.61	60.09	44.87	75
76	61.49	44.67	61.29	44.94	61.09	45.21	60.90	45.47	76
77	62.29	45.26	62.10	45.53	61.90	45.80	61.70	46.07	77
78	63.10	45.85	62.90	46.12	62.70	46.40	62.50	46.67	78
79	63.91	46.43	63.71	46.71	63.50	46.99	63.30	47.27	79
80	64.72	47.02	64.52	47.30	64.31	47.59	64.10	47.87	80
81	65.53	47.61	65.32	47.90	65.11	48.18	64.90	48.46	81
82	66.34	48.20	66.13	48.49	65.92	48.78	65.70	49.06	82
83	67.15	48.79	66.93	49.08	66.72	49.37	66.50	49.66	83
84	67.96	49.37	67.74	49.67	67.52	49.97	67.31	50.26	84
85	68.77	49.96	68.55	50.26	68.33	50.56	68.11	50.86	85
86	69.58	50.55	69.35	50.85	69.13	51.15	68.91	51.46	86
87	70.38	51.14	70.16	51.44	69.94	51.75	69.71	52.05	87
88	71.19	51.73	70.97	52.04	70.74	52.34	70.51	52.65	88
89	72.00	52.31	71.77	52.63	71.54	52.94	71.31	53.25	89
90	72.81	52.90	72.58	53.22	72.35	53.53	72.11	53.85	90
91	73.62	53.49	73.39	53.81	73.15	54.13	72.91	54.45	91
92	74.43	54.08	74.19	54.40	73.95	54.72	73.72	55.05	92
93	75.24	54.66	75.00	54.99	74.76	55.32	74.52	55.64	93
94	76.05	55.25	75.81	55.58	75.56	55.91	75.32	56.24	94
95	76.86	55.84	76.61	56.17	76.37	56.51	76.12	56.84	95
96	77.67	56.43	77.42	56.77	77.17	57.10	76.92	57.44	96
97	78.47	57.02	78.23	57.36	77.97	57.70	77.72	58.04	97
98	79.28	57.60	79.03	57.95	78.78	58.29	78.52	58.64	98
99	80.09	58.19	79.84	58.54	79.58	58.89	79.32	59.23	99
100	80.90	58.78	80.64	59.13	80.39	59.48	80.13	59.83	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	54 Deg.		53¾ Deg.		53½ Deg.		53¼ Deg.		

Distance.	37 Deg.		37¼ Deg.		37½ Deg.		37¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.80	0.60	0.80	0.61	0.79	0.61	0.79	0.61	1
2	1.60	1.20	1.59	1.21	1.59	1.22	1.58	1.22	2
3	2.40	1.81	2.39	1.82	2.38	1.83	2.37	1.84	3
4	3.19	2.41	3.18	2.42	3.17	2.43	3.16	2.45	4
5	3.99	3.01	3.98	3.03	3.97	3.04	3.95	3.06	5
6	4.79	3.61	4.78	3.63	4.76	3.65	4.74	3.67	6
7	5.59	4.21	5.57	4.24	5.55	4.26	5.53	4.29	7
8	6.39	4.81	6.37	4.84	6.35	4.87	6.33	4.90	8
9	7.19	5.42	7.16	5.45	7.14	5.48	7.12	5.51	9
10	7.99	6.02	7.96	6.05	7.93	6.09	7.91	6.12	10
11	8.78	6.62	8.76	6.66	8.73	6.70	8.70	6.73	11
12	9.58	7.22	9.55	7.26	9.52	7.31	9.49	7.35	12
13	10.38	7.82	10.35	7.87	10.31	7.91	10.28	7.96	13
14	11.18	8.43	11.14	8.47	11.11	8.52	11.07	8.57	14
15	11.98	9.03	11.94	9.08	11.90	9.13	11.86	9.18	15
16	12.78	9.63	12.74	9.68	12.69	9.74	12.65	9.80	16
17	13.58	10.23	13.53	10.29	13.49	10.35	13.44	10.41	17
18	14.38	10.83	14.33	10.90	14.28	10.96	14.23	11.02	18
19	15.17	11.43	15.12	11.50	15.07	11.57	15.02	11.63	19
20	15.97	12.04	15.92	12.11	15.87	12.18	15.81	12.24	20
21	16.77	12.64	16.72	12.71	16.66	12.78	16.60	12.86	21
22	17.57	13.24	17.51	13.32	17.45	13.39	17.40	13.47	22
23	18.37	13.84	18.31	13.92	18.25	14.00	18.19	14.08	23
24	19.17	14.44	19.10	14.53	19.04	14.61	18.98	14.69	24
25	19.97	15.05	19.90	15.13	19.83	15.22	19.77	15.31	25
26	20.76	15.65	20.70	15.74	20.63	15.83	20.56	15.92	26
27	21.56	16.25	21.49	16.34	21.42	16.44	21.35	16.53	27
28	22.36	16.85	22.29	16.95	22.21	17.05	22.14	17.14	28
29	23.16	17.45	23.08	17.55	23.01	17.65	22.93	17.75	29
30	23.96	18.05	23.88	18.16	23.80	18.26	23.72	18.37	30
31	24.76	18.66	24.68	18.76	24.59	18.87	24.51	18.98	31
32	25.56	19.26	25.47	19.37	25.39	19.48	25.30	19.59	32
33	26.35	19.86	26.27	19.97	26.18	20.09	26.09	20.20	33
34	27.15	20.46	27.06	20.58	26.97	20.70	26.88	20.82	34
35	27.95	21.06	27.86	21.19	27.77	21.31	27.67	21.43	35
36	28.75	21.67	28.66	21.79	28.56	21.92	28.46	22.04	36
37	29.55	22.27	29.45	22.40	29.35	22.52	29.26	22.65	37
38	30.35	22.87	30.25	23.00	30.15	23.13	30.05	23.26	38
39	31.15	23.47	31.04	23.61	30.94	23.74	30.84	23.88	39
40	31.95	24.07	31.84	24.21	31.73	24.35	31.63	24.49	40
41	32.74	24.67	32.64	24.82	32.53	24.96	32.42	25.10	41
42	33.54	25.28	33.43	25.42	33.32	25.57	33.21	25.71	42
43	34.34	25.88	34.23	26.03	34.11	26.18	34.00	26.33	43
44	35.14	26.48	35.02	26.63	34.91	26.79	34.79	26.94	44
45	35.94	27.08	35.82	27.24	35.70	27.39	35.58	27.55	45
46	36.74	27.68	36.62	27.84	36.49	28.00	36.37	28.16	46
47	37.54	28.29	37.41	28.45	37.29	28.61	37.16	28.77	47
48	38.33	28.89	38.21	29.05	38.08	29.22	37.95	29.39	48
49	39.13	29.49	39.00	29.66	38.87	29.83	38.74	30.00	49
50	39.93	30.09	39.80	30.26	39.67	30.44	39.53	30.61	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	53 Deg.		52¾ Deg.		52½ Deg.		52¼ Deg.		

Distance.	37 Deg.		37¼ Deg.		37½ Deg.		37¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	40.78	30.69	40.60	30.87	40.46	31.05	40.33	31.22	51
52	41.53	31.29	41.39	31.48	41.25	31.66	41.12	31.84	52
53	42.33	31.90	42.19	32.08	42.05	32.26	41.91	32.45	53
54	43.13	32.50	42.98	32.69	42.84	32.87	42.70	33.06	54
55	43.92	33.10	43.78	33.29	43.63	33.48	43.49	33.67	55
56	44.72	33.70	44.58	33.90	44.43	34.09	44.28	34.28	56
57	45.52	34.30	45.37	34.50	45.22	34.70	45.07	34.90	57
58	46.32	34.91	40.17	35.11	46.01	35.31	45.86	35.51	58
59	47.12	35.51	46.96	35.71	46.81	35.92	46.65	36.12	59
60	47.92	36.11	47.76	36.32	47.60	36.53	47.44	36.73	60
61	48.72	36.71	48.56	36.92	48.39	37.13	48.23	37.35	61
62	49.52	37.31	49.35	37.53	49.19	37.74	49.02	37.96	62
63	50.31	37.91	50.15	38.13	49.98	38.35	49.81	38.57	63
64	51.11	38.52	50.94	38.74	50.77	38.96	50.60	39.18	64
65	51.91	39.12	51.74	39.34	51.57	39.57	51.39	39.79	65
66	52.71	39.72	52.54	39.95	52.36	40.18	52.19	40.41	66
67	53.51	40.32	53.33	40.55	53.15	40.79	52.98	41.02	67
68	54.31	40.92	54.13	41.16	53.95	41.40	53.77	41.63	68
69	55.11	41.53	54.92	41.77	54.74	42.00	54.56	42.24	69
70	55.90	42.13	55.72	42.37	55.53	42.61	55.35	42.86	70
71	56.70	42.73	56.52	42.98	56.33	43.22	56.14	43.47	71
72	57.50	43.33	57.31	43.58	57.12	43.83	56.93	44.08	72
73	58.30	43.93	58.11	44.19	57.91	44.44	57.72	44.69	73
74	59.10	44.53	58.90	44.79	58.71	45.05	58.51	45.30	74
75	59.90	45.14	59.70	45.40	59.50	45.66	59.30	45.92	75
76	60.70	45.74	60.50	46.00	60.29	46.27	60.09	46.53	76
77	61.49	46.34	61.29	46.61	61.09	46.87	60.88	47.14	77
78	62.29	46.94	62.09	47.21	61.88	47.48	61.67	47.75	78
79	63.09	47.54	62.88	47.82	62.67	48.09	62.46	48.37	79
80	63.89	48.15	63.68	48.42	63.47	48.70	63.26	48.98	80
81	64.69	48.75	64.48	49.03	64.26	49.31	64.05	49.59	81
82	65.49	49.35	65.27	49.63	65.05	49.92	64.84	50.20	82
83	66.29	49.95	66.07	50.24	65.85	50.53	65.63	50.81	83
84	67.09	50.55	66.86	50.84	66.64	51.14	66.42	51.43	84
85	67.88	51.15	67.66	51.45	67.43	51.74	67.21	52.04	85
86	68.68	51.76	68.46	52.06	68.23	52.35	68.00	52.65	86
87	69.48	52.36	69.25	52.66	69.02	52.96	68.79	53.26	87
88	70.28	52.96	70.05	53.27	69.82	53.57	69.58	53.88	88
89	71.08	53.56	70.84	53.87	70.61	54.18	70.37	54.49	89
90	71.88	54.16	71.64	54.48	71.40	54.79	71.16	55.10	90
91	72.68	54.77	72.44	55.08	72.20	55.40	71.95	55.71	91
92	73.47	55.37	73.23	55.69	72.99	56.01	72.74	56.32	92
93	74.27	55.97	74.03	56.29	73.78	56.61	73.53	56.94	93
94	75.07	56.57	74.82	56.90	74.58	57.22	74.32	57.55	94
95	75.87	57.17	75.62	57.50	75.37	57.83	75.12	58.16	95
96	76.67	57.77	76.42	58.11	76.16	58.44	75.91	58.77	96
97	77.47	58.38	77.21	58.71	76.96	59.05	76.70	59.39	97
98	78.27	58.98	78.01	59.32	77.75	59.66	77.49	60.00	98
99	79.06	59.58	78.80	59.92	78.54	60.27	78.28	60.61	99
100	79.86	60.18	79.60	60.53	79.34	60.88	79.07	61.22	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	53 Deg.		52¾ Deg.		52½ Deg.		52¼ Deg.		

Distance.	38 Deg.		38¼ Deg.		38½ Deg.		38¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.79	0.62	0.79	0.62	0.78	0.62	0.78	0.63	1
2	1.58	1.23	1.57	1.24	1.57	1.24	1.56	1.25	2
3	2.36	1.85	2.36	1.86	2.35	1.87	2.34	1.88	3
4	3.15	2.46	3.14	2.48	3.13	2.49	3.12	2.50	4
5	3.94	3.08	3.93	3.10	3.91	3.11	3.90	3.13	5
6	4.73	3.69	4.71	3.71	4.70	3.74	4.68	3.76	6
7	5.52	4.31	5.50	4.33	5.48	4.36	5.46	4.38	7
8	6.30	4.93	6.28	4.95	6.26	4.98	6.24	5.01	8
9	7.09	5.54	7.07	5.57	7.04	5.60	7.02	5.63	9
10	7.88	6.16	7.85	6.19	7.83	6.23	7.80	6.26	10
11	8.67	6.77	8.64	6.81	8.61	6.85	8.58	6.89	11
12	9.46	7.39	9.42	7.43	9.39	7.47	9.36	7.51	12
13	10.24	8.00	10.21	8.05	10.17	8.09	10.14	8.14	13
14	11.03	8.62	10.99	8.67	10.96	8.72	10.92	8.76	14
15	11.82	9.23	11.78	9.29	11.74	9.34	11.70	9.39	15
16	12.61	9.85	12.57	9.91	12.52	9.96	12.48	10.01	16
17	13.40	10.47	13.35	10.52	13.30	10.58	13.26	10.64	17
18	14.18	11.08	14.14	11.14	14.09	11.21	14.04	11.27	18
19	14.97	11.70	14.92	11.76	14.87	11.83	14.82	11.89	19
20	15.76	12.31	15.71	12.38	15.65	12.45	15.60	12.52	20
21	16.55	12.93	16.49	13.00	16.43	13.07	16.38	13.14	21
22	17.34	13.54	17.28	13.62	17.22	13.70	17.16	13.77	22
23	18.12	14.16	18.06	14.24	18.00	14.32	17.94	14.40	23
24	18.91	14.78	18.85	14.86	18.78	14.94	18.72	15.02	24
25	19.70	15.39	19.63	15.48	19.57	15.56	19.50	15.65	25
26	20.49	16.01	20.42	16.10	20.35	16.19	20.28	16.27	26
27	21.28	16.62	21.20	16.72	21.13	16.81	21.06	16.90	27
28	22.06	17.24	21.99	17.33	21.91	17.43	21.84	17.53	28
29	22.85	17.85	22.77	17.95	22.70	18.05	22.62	18.15	29
30	23.64	18.47	23.56	18.57	23.48	18.68	23.40	18.78	30
31	24.43	19.09	24.34	19.19	24.26	19.30	24.18	19.40	31
32	25.22	19.70	25.13	19.81	25.04	19.92	24.96	20.03	32
33	26.00	20.32	25.92	20.43	25.83	20.54	25.74	20.66	33
34	26.79	20.93	26.70	21.05	26.61	21.17	26.52	21.28	34
35	27.58	21.55	27.49	21.67	27.39	21.79	27.30	21.91	35
36	28.37	22.16	28.27	22.29	28.17	22.41	28.08	22.53	36
37	29.16	22.78	29.06	22.91	28.96	23.03	28.86	23.16	37
38	29.94	23.40	29.84	23.53	29.74	23.66	29.64	23.79	38
39	30.73	24.01	30.63	24.14	30.52	24.28	30.42	24.41	39
40	31.52	24.63	31.41	24.76	31.30	24.90	31.20	25.04	40
41	32.31	25.24	32.20	25.38	32.09	25.52	31.98	25.66	41
42	33.10	25.86	32.98	26.00	32.87	26.15	32.76	26.29	42
43	33.88	26.47	33.77	26.62	33.65	26.77	33.53	26.91	43
44	34.67	27.09	34.55	27.24	34.43	27.39	34.31	27.54	44
45	35.46	27.70	35.34	27.86	35.22	28.01	35.09	28.17	45
46	36.25	28.32	36.12	28.48	36.00	28.64	35.87	28.79	46
47	37.04	28.94	36.91	29.10	36.78	29.26	36.65	29.42	47
48	37.82	29.55	37.70	29.72	37.57	29.88	37.43	30.04	48
49	38.61	30.17	38.48	30.34	38.35	30.50	38.21	30.67	49
50	39.40	30.78	39.27	30.95	39.13	31.13	38.99	31.30	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	52 Deg		51¾ Deg.		51½ Deg.		51¼ Deg.		

Distance.	38 Deg. Lat.	38 Deg. Dep.	38¼ Deg. Lat.	38¼ Deg. Dep.	38½ Deg. Lat.	38½ Deg. Dep.	38¾ Deg. Lat.	38¾ Deg. Dep.	Distance.
51	40.19	31.40	40.05	31.57	39.91	31.75	39.77	31.92	51
52	40.98	32.01	40.84	32.19	40.70	32.37	40.55	32.55	52
53	41.76	32.63	41.62	32.81	41.48	32.99	41.33	33.17	53
54	42.55	33.25	42.41	33.43	42.26	33.62	42.11	33.80	54
55	43.34	33.86	43.19	34.05	43.04	34.24	42.89	34.43	55
56	44.13	34.48	43.98	34.67	43.83	34.86	43.67	35.05	56
57	44.92	35.09	44.76	35.29	44.61	35.48	44.45	35.68	57
58	45.70	35.71	45.55	35.91	45.39	36.11	45.23	36.30	58
59	46.49	36.32	46.33	36.53	46.17	36.73	46.01	36.93	59
60	47.28	36.94	47.12	37.15	46.96	37.35	46.79	37.56	60
61	48.07	37.56	47.90	37.76	47.74	37.97	47.57	38.18	61
62	48.86	38.17	48.69	38.38	48.52	38.60	48.35	38.81	62
63	49.64	38.79	49.47	39.00	49.30	39.22	49.13	39.43	63
64	50.43	39.40	50.26	39.62	50.09	39.84	49.91	40.06	64
65	51.22	40.02	51.05	40.24	50.87	40.46	50.69	40.68	65
66	52.01	40.63	51.83	40.86	51.65	41.09	51.47	41.31	66
67	52.80	41.25	52.62	41.48	52.43	41.71	52.25	41.94	67
68	53.58	41.86	53.40	42.10	53.22	42.33	53.03	42.56	68
69	54.37	42.48	54.19	42.72	54.00	42.95	53.81	43.19	69
70	55.16	43.10	54.97	43.34	54.78	43.58	54.59	43.81	70
71	55.95	43.71	55.76	43.96	55.57	44.20	55.37	44 4	71
72	56.74	44.33	56.54	44.57	56.35	44.82	56.15	4/ 07	72
73	57.52	44.94	57.33	45.19	57.13	45.44	56.93	4.69	73
74	58.31	45.56	58.11	45.81	57.91	46.07	57.71	46.32	74
75	59.10	46.17	58.90	46.43	58.70	46.69	58.49	46.94	75
76	59.89	46.79	59.68	47.05	59.48	47.31	59.27	47.57	76
77	60.68	47.41	60.47	47.67	60.26	47.93	60 05	48.20	77
78	61.46	48.02	61.25	48.29	61.04	48.56	60 83	48.82	78
79	62.25	48.64	62.04	48.91	61.83	49.18	6 .61	49.45	79
80	63.04	49.25	62.83	49.53	62.61	49.80	62.39	50.07	80
81	63.83	49.87	63.61	50.15	63.39	50.42	63.17	50.70	81
82	64.62	50.48	64.40	50.77	64.17	51.05	63.95	51.33	82
83	65.40	51.10	65.18	51.38	64.96	51.67	64.73	51.95	83
84	66.19	51.72	65.97	52.00	65.74	52.29	65.51	52.58	84
85	66.98	52.33	66.75	52.62	66.52	52.91	66.29	53.20	85
86	67.77	52.95	67.54	53.24	67.30	53.54	67.07	53.83	86
87	68.56	53.56	68.32	53.86	68.09	54.16	67.85	54.46	87
88	69.34	54.18	69.11	54.48	68.87	54.78	68.63	55.08	88
89	70.13	54.79	69.89	55.10	69.65	55.40	69.41	55.71	89
90	70.92	55.41	70.68	55.72	70.43	56.03	70.19	56.33	90
91	71.71	56.03	71.46	56.34	71.22	56.65	70.97	56.96	91
92	72.50	56.64	72.25	56.96	72.00	57.27	71.75	57.58	92
93	73.28	57.26	73.03	57.58	72.78	57.89	72.53	58.21	93
94	74.07	57.87	73.82	58.19	73.57	58.52	73.31	58.84	94
95	74.86	58.49	74.61	58.81	74.35	59.14	74.09	59.46	95
96	75.65	59.10	75.39	59.43	75.13	59.76	74.87	60.09	96
97	76.44	59.72	76.18	60.05	75.91	60.38	75.65	60.71	97
98	77.22	60.33	76.96	60.67	76.70	61.01	76.43	61.34	98
99	78.01	60.95	77.75	61.29	77.48	61.63	77.21	61.97	99
100	78.80	61.57	78.53	61.91	78.26	62.25	77.99	62.59	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	52 Deg.		51¾ Deg.		51½ Deg.		51¼ Deg.		

Distance.	39 Deg.		39¼ Deg.		39½ Deg.		39¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.78	0.63	0.77	0.63	0.77	0.64	0.77	0.64	1
2	1.55	1.26	1.55	1.27	1.54	1.27	1.54	1.28	2
3	2.33	1.89	2.32	1.90	2.31	1.91	2.31	1.92	3
4	3.11	2.52	3.10	2.53	3.09	2.54	3.08	2.56	4
5	3.89	3.15	3.87	3.16	3.86	3.18	3.84	3.20	5
6	4.66	3.78	4.65	3.80	4.63	3.82	4.61	3.84	6
7	5.44	4.41	5.42	4.43	5.40	4.45	5.38	4.48	7
8	6.22	5.03	6.20	5.06	6.17	5.09	6.15	5.12	8
9	6.99	5.66	6.97	5.69	6.94	5.72	6.92	5.75	9
10	7.77	6.29	7.74	6.33	7.72	6.36	7.69	6.39	10
11	8.55	6.92	8.52	6.96	8.49	7.00	8.46	7.03	11
12	9.33	7.55	9.29	7.59	9.26	7.63	9.23	7.67	12
13	10.10	8.18	10.07	8.23	10.03	8.27	9.99	8.31	13
14	10.88	8.81	10.84	8.86	10.80	8.91	10.76	8.95	14
15	11.66	9.44	11.62	9.49	11.57	9.54	11.53	9.59	15
16	12.43	10.07	12.39	10.12	12.35	10.18	12.30	10.23	16
17	13.21	10.70	13.16	10.76	13.12	10.81	13.07	10.87	17
18	13.99	11.33	13.94	11.39	13.89	11.45	13.84	11.51	18
19	14.77	11.96	14.71	12.02	14.66	12.09	14.61	12.15	19
20	15.54	12.59	15.49	12.65	15.43	12.72	15.38	12.79	20
21	16.32	13.22	16.26	13.29	16.20	13.35	16.15	13.43	21
22	17.10	13.84	17.04	13.92	16.98	13.99	16.91	14.07	22
23	17.87	14.47	17.81	14.55	17.75	14.63	17.68	14.71	23
24	18.65	15.10	18.59	15.18	18.52	15.27	18.45	15.35	24
25	19.43	15.73	19.36	15.82	19.29	15.90	19.22	15.99	25
26	20.21	16.36	20.13	16.45	20.06	16.54	19.39	16.63	26
27	20.98	16.99	20.91	17.08	20.83	17.17	20.76	17.26	27
28	21.76	17.62	21.68	17.72	21.61	17.81	21.53	17.90	28
29	22.54	18.25	22.46	18.35	22.38	18.45	22.30	18.54	29
30	23.31	18.88	23.23	18.98	23.15	19.08	23.07	19.18	30
31	24.09	19.51	24.01	19.61	23.92	19.72	23.83	19.82	31
32	24.87	20.14	24.78	20.25	24.69	20.35	24.60	20.46	32
33	25.65	20.77	25.55	20.88	25.46	20.99	25.37	21.10	33
34	26.42	21.40	26.33	21.51	26.24	21.63	26.14	21.74	34
35	27.20	22.03	27.10	22.14	37.01	22.26	26.91	22.38	35
36	27.98	22.66	27.88	22.78	27.78	22.90	27.68	23.02	36
37	28.75	23.28	28.65	23.41	28.55	23.53	28.45	23.66	37
38	29.53	23.91	29.43	24.04	29.32	24.17	29.22	24.30	38
39	30.31	24.54	30.20	24.68	30.09	24.81	29.98	24.94	39
40	31.09	25.17	30.98	25.31	30.86	25.44	30.75	25.58	40
41	31.86	25.80	31.75	25.94	31.64	26.08	31.52	26.22	41
42	32.64	26.43	32 52	26.57	32.41	26.72	32.29	26.86	42
43	33.42	27.06	33.30	27.21	33.18	27.35	33.06	27.50	43
44	34.19	27.69	34.07	27.84	33.95	27.99	33.83	28.14	44
45	34.97	28.32	34.85	28.47	34.72	28.62	34.60	28.77	45
46	35.75	28.95	35.62	29.10	35.49	29.26	35.37	29.41	46
47	36.53	29.58	36.40	29.74	36.27	29.90	36.14	30.05	47
48	37.30	30.21	37.17	30.37	37.04	30.53	36.90	30.69	48
49	38.08	30.84	37.95	31.00	37.81	31.17	37.67	31.33	49
50	38.86	31.47	38.72	31.64	38.58	31.80	38.44	31.97	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	51 Deg.		50¾ Deg.		50½ Deg.		50¼ Deg.		

Distance.	39 Deg.		39¼ Deg.		39½ Deg.		39¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	39.63	32.10	39.49	32.27	39.35	32.44	39.21	32.61	51
52	40.41	32.72	40.27	32.90	40.12	33.08	39.98	33.25	52
53	41.19	33.35	41 04	33.53	40.90	33.71	40.75	33.89	53
54	41.97	33.98	41.82	34.17	41.67	34.35	41.52	34.53	54
55	42.74	34.61	42.59	34.80	42.44	34.98	42.29	35.17	55
56	43.52	35.24	43.37	35.43	43.21	35.62	43.06	35.81	56
57	44.30	35.87	44.14	36.06	43.98	36.26	43.82	36.45	57
58	45.07	36.50	44.91	36.70	44.75	36.89	44.59	37.09	58
59	45.85	37.13	45.69	37.33	45.53	37.53	45.36	37.73	59
60	46.63	37.76	46.46	37.96	46.30	38.16	46.13	38.37	60
61	47.41	38.39	47.24	38.60	47.07	38.80	46.90	39.01	61
62	48.18	39.02	48.01	39.23	47.84	39.44	47.67	39.65	62
63	48.96	39.65	48.79	39.86	48.61	40.07	48.44	40.28	63
64	49.74	40.28	49.56	40.49	49.38	40.71	49.21	40.92	64
65	50.51	40.91	50.34	41.13	50.16	41.35	49.97	41.56	65
66	51.29	41.54	51.11	41.76	50.93	41.98	50.74	42.20	66
67	52.07	42.16	51.88	42.39	51.70	42.62	51.51	42.84	67
68	52.85	42.79	52.66	43.02	52.47	43.25	52.28	43.48	68
69	53.62	43.42	53.43	43.66	53.24	43.89	53.05	44.12	69
70	54.40	44.05	54.21	44.29	54.01	44.53	53.82	44.76	70
71	55.18	44.68	54.98	44.92	54.79	45.16	54.59	45.40	71
72	55.95	45.31	55.76	45.55	55.56	45.80	55.36	46.04	72
73	56.73	45.94	56.53	46.19	56.33	46.43	56.13	46.68	73
74	57.51	46.57	57.31	46.82	57.10	47.07	56.89	47.32	74
75	58.29	47.20	58.08	47.45	57.87	47.71	57.66	47.96	75
76	59.06	47.83	58.85	48.09	58.64	48.34	58.43	48.60	76
77	59.84	48.46	59.63	48.72	59.42	48.98	59.20	49.24	77
78	60.62	49.09	60.40	49.35	60.19	49.61	59.97	49.88	78
79	61.39	49.72	61.18	49.98	60.96	50.25	60.74	50.52	79
80	62.17	50.35	61.95	50.62	61.73	50.89	61.51	51.16	80
81	62.95	50.97	62.73	51.25	62.50	51.52	62.28	51.79	81
82	63.73	51.60	63.50	51.88	63.27	52.16	63.04	52.43	82
83	64.50	52.23	64.27	52.51	64.04	52.79	63.81	53.07	83
84	65.28	52.86	65.05	53.15	64.82	53.43	64.58	53.71	84
85	66.06	53.49	65.82	53.78	65.59	54.07	65.35	54.35	85
86	66.83	54.12	66.60	54.41	66.36	54.70	66.12	54.99	86
87	67.61	54.75	67.37	55.05	67.13	55.34	66.89	55.63	87
88	68.39	55.38	68.15	55.68	67.90	55.97	67.66	56.27	88
89	69.17	56.01	68.92	56.32	68.67	56.61	68.43	56.91	89
90	69.94	56.64	69.70	56.94	69.45	57.25	69.20	57.55	90
91	70.72	57.27	70.47	57.58	70.22	57.88	69.96	58.19	91
92	71.50	57.90	71.24	58.21	70.99	58.52	70.73	58.83	92
93	72.27	58.53	72.02	58.84	71.76	59.16	71.50	59.47	93
94	73.05	59.16	72.79	59.47	72.53	59.79	72.27	60.11	94
95	73.83	59.79	73.57	60.11	73.30	60.43	73.04	60.75	95
96	74.61	60.41	74.34	60.74	74.08	61.06	73.81	61.39	96
97	75.38	61.04	75.12	61.37	74.85	61.70	74.58	62.03	97
98	76.16	61.67	75.89	62.01	75.62	62.34	75.35	62.66	98
99	76.94	62.30	76.66	62.64	76.39	62.97	76.12	63.30	99
100	77.71	62.93	77.44	63.27	77.16	63.61	76.88	63.94	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	51 Deg.		50¾ Deg.		50½ Deg.		50¼ Deg.		

Distance.	40 Deg. Lat.	40 Deg. Dep.	40¼ Deg. Lat.	40¼ Deg. Dep.	40½ Deg. Lat.	40½ Deg. Dep.	40¾ Deg. Lat.	40¾ Deg. Dep.	Distance.
1	0.77	0.64	0.76	0.65	0.76	0.65	0.76	0.65	1
2	1.53	1.29	1.53	1.29	1.52	1.30	1.52	1.31	2
3	2.30	1.93	2.29	1.94	2.28	1.95	2.27	1.96	3
4	3.06	2.57	3.05	2.58	3.04	2.60	3.03	2.61	4
5	3.83	3.21	3.82	3.23	3.80	3.25	3.79	3.26	5
6	4.60	3.86	4.58	3.88	4.56	3.90	4.55	3.92	6
7	5.36	4.50	5.34	4.52	5.32	4.55	5.30	4.57	7
8	6.13	5.14	6.11	5.17	6.08	5.20	6.06	5.22	8
9	6.89	5.79	6.87	5.82	6.84	5.84	6.82	5.87	9
10	7.66	6.43	7.63	6.46	7.60	6.49	7.58	6.53	10
11	8.43	7.07	8.40	7.11	8.36	7.14	8.33	7.18	11
12	9.19	7.71	9.16	7.75	9.12	7.79	9.09	7.83	12
13	9.96	8.36	9.92	8.40	9.89	8.44	9.85	8.49	13
14	10.72	9.00	10.69	9.05	10.65	9.09	10.61	9.14	14
15	11.49	9.64	11.45	9.69	11.41	9.74	11.36	9.79	15
16	12.26	10.28	12.21	10.34	12.17	10.39	12.12	10.44	16
17	13.02	10.93	12.97	10.98	12.93	11.04	12.88	11.10	17
18	13.79	11.57	13.74	11.63	13.69	11.69	13.64	11.75	18
19	14.55	12.21	14.50	12.28	14.45	12.34	14.39	12.40	19
20	15.32	12.86	15.26	12.92	15.21	12.99	15.15	13.06	20
21	16.09	13.50	16.03	13.57	15.97	13.64	15.91	13.71	21
22	16.85	14.14	16.79	14.21	16.73	14.29	16.67	14.36	22
23	17.62	14.78	17.55	14.86	17.49	14.94	17.42	15.01	23
24	18.39	15.43	18.32	15.51	18.25	15.59	18.18	15.67	24
25	19.15	16.07	19.08	16.15	19.01	16.24	18.94	16.32	25
26	19.92	16.71	19.84	16.80	19.77	16.89	19.70	16.97	26
27	20.68	17.36	20.61	17.45	20.53	17.54	20.45	17.62	27
28	21.45	18.00	21.37	18.09	21.29	18.18	21.21	18.28	28
29	22.22	18.64	22.13	18.74	22.05	18.83	21.97	18.93	29
30	22.98	19.28	22.90	19.38	22.81	19.48	22.73	19.58	30
31	23.75	19.93	23.66	20.03	23.57	20.13	23.48	20.24	31
32	24.51	20.57	24.42	20.68	24.33	20.78	24.24	20.89	32
33	25.28	21.21	25.19	21.32	25.09	21.43	25.00	21.54	33
34	26.05	21.85	25.95	21.97	25.85	22.08	25.76	22.19	34
35	26.81	22.50	26.71	22.61	26.61	22.73	26.51	22.85	35
36	27.58	23.14	27.48	23.26	27.37	23.38	27.27	23.50	36
37	28.34	23.78	28.24	23.91	28.13	24.03	28.03	24.15	37
38	29.11	24.43	29.00	24.55	28.90	24.68	28.79	24.80	38
39	29.88	25.07	29.77	25.20	29.66	25.33	29.54	25.46	39
40	30.64	25.71	30.53	25.84	30.42	25.98	30.30	26.11	40
41	31.41	26.35	31.29	26.49	31.18	26.63	31.06	26.76	41
42	32.17	27.00	32.06	27.14	31.94	27.28	31.82	27.42	42
43	32.94	27.64	32.82	27.78	32.70	27.93	32.58	28.07	43
44	33.71	28.28	33.58	28.43	33.46	28.58	33.33	28.72	44
45	34.47	28.93	34.35	29.08	34.22	29.23	34.09	29.37	45
46	35.24	29.57	35.11	29.72	34.98	29.87	34.85	30.03	46
47	36.00	30.21	35.87	30.37	35.74	30.52	35.61	30.68	47
48	36.77	30.85	36.64	31.01	36.50	31.17	36.36	31.33	48
49	37.54	31.50	37.40	31.66	37.26	31.82	37.12	31.99	49
50	38.30	32.14	38.16	32.31	38.02	32.47	37.88	32.64	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	50 Deg.		49¾ Deg.		49½ Deg.		49¼ Deg.		

Distance.	40 Deg. Lat.	40 Deg. Dep.	40¼ Deg. Lat.	40¼ Deg. Dep.	40½ Deg. Lat.	40½ Deg. Dep.	40¾ Deg. Lat.	40¾ Deg. Dep.	Distance.
51	39.07	32.78	38.92	32.95	38.78	33.12	38.64	33.29	51
52	39.83	33.42	39.69	33.60	39.54	33.77	39.39	33.94	52
53	40.60	34.07	40.45	34.24	40.30	34.42	40.15	34.60	53
54	41.37	34.71	41.21	34.89	41.06	35.07	40.91	35.25	54
55	42.13	35.35	41.98	35.54	41.82	35.72	41.67	35.90	55
56	42.90	36.00	42.74	36.18	42.58	36.37	42.42	36.55	56
57	43.66	36.64	43.50	36.83	43.34	37.02	43.18	37.21	57
58	44.43	37.28	44.27	37.48	44.10	37.67	43.94	37.86	58
59	45.20	37.92	45.03	38.12	44.86	38.32	44.70	38.51	59
60	45.96	38.57	45.79	38.77	45.62	38.97	45.45	39.17	60
61	46.73	39.21	46.56	39.41	46.38	39.62	46.21	39.82	61
62	47.49	39.85	47.32	40.06	47.15	40.27	46.97	40.47	62
63	48.26	40.50	48.08	40.71	47.91	40.92	47.73	41.12	63
64	49.03	41.14	48.85	41.35	48.67	41.56	48.48	41.78	64
65	49.79	41.78	49.61	42.00	49.43	42.21	49.24	42.43	65
66	50.56	42.42	50.37	42.64	50.19	42.86	50.00	43.08	66
67	51.32	43.07	51.14	43.29	50.95	43.51	50.76	43.73	67
68	52.09	43.71	51.90	43.94	51.71	44.16	51.51	44.39	68
69	52.86	44.35	52.66	44.58	52.47	44.81	52.27	45.04	69
70	53.62	45.00	53.43	45.23	53.23	45.46	53.03	45.69	70
71	54.39	45.64	54.19	45.87	53.99	46.11	53.79	46.35	71
72	55.16	46.28	54.95	46.52	54.75	46.76	54.54	47.00	72
73	55.92	46.92	55.72	47.17	55.51	47.41	55.30	47.65	73
74	56.69	47.57	56.48	47.81	56.27	48.06	56.06	48.30	74
75	57.45	48.21	57.24	48.46	57.03	48.71	56.82	48.96	75
76	58.22	48.85	58.01	49.11	57.79	49.36	57.57	49.61	76
77	58.99	49.49	58.77	49.75	58.55	50.01	58.33	50.26	77
78	59.75	50.14	59.53	50.40	59.31	50.66	59.09	50.92	78
79	60.52	50.78	60.30	51.04	60.07	51.31	59.85	51.57	79
80	61.28	51.42	61.06	51.69	60.83	51.96	60.61	52.22	80
81	62.05	52.07	61.82	52.34	61.59	52.61	61.36	52.87	81
82	62.82	52.71	62.59	52.98	62.35	53.25	62.12	53.53	82
83	63.58	53.35	63.35	53.63	63.11	53.90	62.88	54.18	83
84	64.35	53.99	64.11	54.27	63.87	54.55	63.64	54.83	84
85	65.11	54.64	64.87	54.92	64.63	55.20	64.39	55.48	85
86	65.88	55.28	65.64	55.57	65.39	55.85	65.15	56.14	86
87	66.65	55.92	66.40	56.21	66.16	56.50	65.91	56.79	87
88	67.41	56.57	67.16	56.86	66.92	57.15	66.67	57.44	88
89	68.18	57.21	67.93	57.50	67.68	57.80	67.42	58.10	89
90	68.94	57.85	68.69	58.15	68.44	58.45	68.18	58.75	90
91	69.71	58.49	69.45	58.80	69.20	59.10	68.94	59.40	91
92	70.48	59.14	70.22	59.44	69.96	59.75	69.70	60.05	92
93	71.24	59.78	70.98	60.09	70.72	60.40	70.45	60.71	93
94	72.01	60.42	71.74	60.74	71.48	61.05	71.21	61.36	94
95	72.77	61.06	72.51	61.38	72.24	61.70	71.97	62.01	95
96	73.54	61.71	73.27	62.03	73.00	62.35	72.73	62.66	96
97	74.31	62.35	74.03	62.67	73.76	63.00	73.48	63.32	97
98	75.07	62.99	74.80	63.32	74.52	63.65	74.24	63.97	98
99	75.84	63.64	75.56	63.97	75.28	64.30	75.00	64.62	99
100	76.60	64.28	76.32	64.61	76.04	64.94	75.76	65.28	100
Distance.	50 Deg. Dep.	50 Deg. Lat.	49¾ Deg. Dep.	49¾ Deg. Lat.	49½ Deg. Dep.	49½ Deg. Lat.	49¼ Deg. Dep.	49¼ Deg. Lat.	Distance.

Distance.	41 Deg.		41¼ Deg.		41½ Deg.		41¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.75	0.66	0.75	0.66	0.75	0.66	0.75	0.67	1
2	1.51	1.31	1.50	1.32	1.50	1.33	1.49	1.33	2
3	2.26	1.97	2.26	1.98	2.25	1.99	2.24	2.00	3
4	3.02	2.62	3.01	2.64	3.00	2.65	2.98	2.66	4
5	3.77	3.28	3.76	3.30	3.74	3.31	3.73	3.33	5
6	4.53	3.94	4.51	3.96	4.49	3.98	4.48	4.00	6
7	5.28	4.59	5.26	4.62	5.24	4.64	5.22	4.66	7
8	6.04	5.25	6.01	5.27	5.99	5.30	5.97	5.33	8
9	6.79	5.90	6.77	5.93	6.74	5.96	6.71	5.99	9
10	7.55	6.56	7.52	6.59	7.49	6.63	7.46	6.66	10
11	8.30	7.22	8.27	7.25	8.24	7.29	8.21	7.32	11
12	9.06	7.87	9.02	7.91	8.99	7.95	8.95	7.99	12
13	9.81	8.53	9.77	8.57	9.74	8.61	9.70	8.66	13
14	10.57	9.18	10.53	9.23	10.49	9.28	10.44	9.32	14
15	11.32	9.84	11.28	9.89	11.23	9.94	11.19	9.99	15
16	12.08	10.50	12.03	10.55	11.98	10.60	11.94	10.65	16
17	12.83	11.15	12.78	11.21	12.73	11.26	12.68	11.32	17
18	13.58	11.81	13.53	11.87	13.48	11.93	13.43	11.99	18
19	14.34	12.47	14.28	12.53	14.23	12.59	14.18	12.65	19
20	15.09	13.12	15.04	13.19	14.98	13.25	14.92	13.32	20
21	15.85	13.78	15.79	13.85	15.73	13.91	15.67	13.98	21
22	16.60	14.43	16.54	14.51	16.48	14.58	16.41	14.65	22
23	17.36	15.09	17.29	15.16	17.23	15.24	17.16	15.32	23
24	18.11	15.75	18.04	15.82	17.97	15.90	17.91	15.98	24
25	18.87	16.40	18.80	16.48	18.72	16.57	18.65	16.65	25
26	19.62	17.06	19.55	17.14	19.47	17.23	19.40	17.31	26
27	20.38	17.71	20.30	17.80	20.22	17.89	20.14	17.98	27
28	21.13	18.37	21.05	18.46	20.97	18.55	20.89	18.64	28
29	21.89	19.03	21.80	19.12	21.72	19.22	21.64	19.31	29
30	22.64	19.68	22.56	19.78	22.47	19.88	22.38	19.98	30
31	23.40	20.34	23.31	20.44	23.22	20.54	23.13	20.64	31
32	24.15	20.99	24.06	21.10	23.97	21.20	23.87	21.31	32
33	24.91	21.65	24.81	21.76	24.72	21.87	24.62	21.97	33
34	25.66	22.31	25.56	22.42	25.46	22.53	25.37	22.64	34
35	26.41	22.96	26.31	23.08	26.21	23.19	26.11	23.31	35
36	27.17	23.62	27.07	23.74	26.96	23.85	26.86	23.97	36
37	27.92	24.27	27.82	24.40	27.71	24.52	27.60	24.64	37
38	28.68	24.93	28.57	25.06	28.46	25.18	28.35	25.30	38
39	29.43	25.59	29.32	25.71	29.21	25.84	29.10	25.97	39
40	30.19	26.24	30.07	26.37	29.96	26.50	29.84	26.64	40
41	30.94	26.90	30.83	27.03	30.71	27.17	30.59	27.30	41
42	31.70	27.55	31.58	27.69	31.46	27.83	31.33	27.97	42
43	32.45	28.21	32.33	28.35	32.21	28.49	32.08	28.63	43
44	33.21	28.87	33.08	29.01	32.95	29.16	32.83	29.30	44
45	33.96	29.52	33.83	29.67	33.70	29.82	33.57	29.97	45
46	34.72	30.18	34.58	30.33	34.45	30.48	34.32	30.63	46
47	35.47	30.83	35.34	30.99	35.20	31.14	35.06	31.30	47
48	36.23	31.49	36.09	31.65	35.95	31.81	35.81	31.96	48
49	36.98	32.15	36.84	32.31	36.70	32.47	36.56	32.63	49
50	37.74	32.80	37.59	32.97	37.45	33.13	37.30	33.29	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	49 Deg.		48¾ Deg.		48½ Deg.		48¼ Deg.		

Distance.	41 Deg.		41¼ Deg.		41½ Deg.		41¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	38.49	33.46	38.34	33.63	38.20	33.79	38.05	33.96	51
52	39.24	34.12	39.10	34.29	38.95	34.46	38.79	34.63	52
53	40.00	34.77	39.85	34.95	39.69	35.12	39.54	35.29	53
54	40.75	35.43	40.60	35.60	40.44	35.78	40.29	35.96	54
55	41.51	36.08	41.35	36.26	41.19	36.44	41.03	36.62	55
56	42.26	36.74	42.10	36.92	41.94	37.11	41.78	37.29	56
57	43.02	37.40	42.85	37.58	42.69	37.77	42.53	37.96	57
58	43.77	38.05	43.61	38.24	43.44	38.43	43.27	38.62	58
59	44.53	38.71	44.36	38.90	44.19	39.09	44.02	39.29	59
60	45.28	39.36	45.11	39.56	44.94	39.76	44.76	39.95	60
61	46.04	40.02	45.86	40.22	45.69	40.42	45.51	40.62	61
62	46.79	40.68	46.61	40.88	46.44	41.08	46.26	41.28	62
63	47.55	41.33	47.37	41.54	47.18	41.75	47.00	41.95	63
64	48.30	41.99	48.12	42.20	47.93	42.41	47.75	42.62	64
65	49.06	42.64	48.87	42.86	48.68	43.07	48.49	43.28	65
66	49.81	43.30	49.62	43.52	49.43	43.73	49.24	43.95	66
67	50.57	43.96	50.37	44.18	50.18	44.40	49.99	44.61	67
68	51.32	44.61	51.13	44.84	50.93	45.06	50.73	45.28	68
69	52.07	45.27	51.88	45.49	51.68	45.72	51.48	45.95	69
70	52.83	45.92	52.63	46.15	52.43	46.38	52.22	46.61	70
71	53.58	46.58	53.38	46.81	53.18	47.05	52.97	47.28	71
72	54.34	47.24	54.13	47.47	53.92	47.71	53.72	47.94	72
73	55.09	47.89	54.88	48.13	54.67	48.37	54.46	48.61	73
74	55.85	48.55	55.64	48.79	55.42	49.03	55.21	49.28	74
75	56.60	49.20	56.39	49.45	56.17	49.70	55.95	49.94	75
76	57.36	49.86	57.14	50.11	56.92	50.36	56.70	50.61	76
77	58.11	50.52	57.89	50.77	57.67	51.02	57.45	51.27	77
78	58.87	51.17	58.64	51.43	58.42	51.68	58.19	51.94	78
79	59.62	51.83	59.40	52.09	59.17	52.35	58.94	52.60	79
80	60.38	52.48	60.15	52.75	59.92	53.01	59.68	53.27	80
81	61.13	53.14	60.90	53.41	60.67	53.67	60.43	53.94	81
82	61.89	53.80	61.65	54.07	61.41	54.33	61.18	54.60	82
83	62.64	54.45	62.40	54.73	62.16	55.00	61.92	55.27	83
84	63.40	55.11	63.15	55.38	62.91	55.66	62.67	55.93	84
85	64.15	55.76	63.91	56.04	63.66	56.32	63.41	56.60	85
86	64.90	56.42	64.66	56.70	64.41	56.99	64.16	57.27	86
87	65.66	57.08	65.41	57.36	65.16	57.65	64.91	57.93	87
88	66.41	57.73	66.16	58.02	65.91	58.31	65.65	58.60	88
89	67.17	58.39	66.91	58.68	66.66	58.97	66.40	59.26	89
90	67.92	59.05	67.67	59.34	67.41	59.64	67.15	59.93	90
91	68.68	59.70	68.42	60.00	68.15	60.30	67.89	60.60	91
92	69.43	60.36	69.17	60.66	68.90	60.96	68.64	61.26	92
93	70.19	61.01	69.92	61.32	69.65	61.62	69.38	61.93	93
94	70.94	61.67	70.67	61.98	70.40	62.29	70.13	62.59	94
95	71.70	62.33	71.43	62.64	71.15	62.95	70.88	63.26	95
96	72.45	62.98	72.18	63.30	71.90	63.61	71.62	63.92	96
97	73.21	63.64	72.93	63.96	72.65	64.27	72.37	64.59	97
98	73.96	64.29	73.68	64.62	73.40	64.94	73.11	65.26	98
99	74.72	64.95	74.43	65.28	74.15	65.60	73.86	65.92	99
100	75.47	65.61	75.18	65.93	74.90	66.26	74.61	66.59	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	49 Deg.		48¾ Deg.		48½ Deg.		48¼ Deg.		

Distance.	42 Deg.		42¼ Deg.		42½ Deg.		42¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.74	0.67	0.74	0.67	0.74	0.68	0.73	0.68	1
2	1.49	1.34	1.48	1.34	1.47	1.35	1.47	1.36	2
3	2.23	2.01	2.22	2.02	2.21	2.03	2.20	2.04	3
4	2.97	2.68	2.96	2.69	2.95	2.70	2.94	2.72	4
5	3.72	3.35	3.70	3.36	3.69	3.38	3.67	3.39	5
6	4.46	4.01	4.44	4.03	4.42	4.05	4.41	4.07	6
7	5.20	4.68	5.18	4.71	5.16	4.73	5.14	4.75	7
8	5.95	5.35	5.92	5.38	5.90	5.40	5.87	5.43	8
9	6.69	6.02	6.66	6.05	6.64	6.08	6.61	6.11	9
10	7.43	6.69	7.40	6.72	7.37	6.76	7.34	6.79	10
11	8.17	7.36	8.14	7.40	8.11	7.43	8.08	7.47	11
12	8.92	8.03	8.88	8.07	8.85	8.11	8.81	8.15	12
13	9.66	8.70	9.62	8.74	9.58	8.78	9.55	8.82	13
14	10.40	9.37	10.36	9.41	10.32	9.46	10.28	9.50	14
15	11.15	10.04	11.10	10.09	11.06	10.13	11.01	10.18	15
16	11.89	10.71	11.84	10.76	11.80	10.81	11.75	10.86	16
17	12.63	11.38	12.58	11.43	12.53	11.48	12.48	11.54	17
18	13.38	12.04	13.32	12.10	13.27	12.16	13.22	12.22	18
19	14.12	12.71	14.06	12.77	14.01	12.84	13.95	12.90	19
20	14.86	13.38	14.80	13.45	14.75	13.51	14.69	13.58	20
21	15.61	14.05	15.54	14.12	15.48	14.19	15.42	14.25	21
22	16.35	14.72	16.28	14.79	16.22	14.86	16.16	14.93	22
23	17.09	15.39	17.02	15.46	16.96	15.54	16.89	15.61	23
24	17.84	16.06	17.77	16.14	17.69	16.21	17.62	16.29	24
25	18.58	16.73	18.51	16.81	18.43	16.89	18.36	16.97	25
26	19.32	17.40	19.25	17.48	19.17	17.57	19.09	17.65	26
27	20.06	18.07	19.99	18.15	19.91	18.24	19.83	18.33	27
28	20.81	18.74	20.73	18.83	20.64	18.92	20.56	19.01	28
29	21.55	19.40	21.47	19.50	21.38	19.59	21.30	19.69	29
30	22.29	20.07	22.21	20.17	22.12	20.27	22.03	20.36	30
31	23.04	20.74	22.95	20.84	22.86	20.94	22.76	21.04	31
32	23.78	21.41	23.69	21.52	23.59	21.62	23.50	21.72	32
33	24.52	22.08	24.43	22.19	24.33	22.29	24.23	22.40	33
34	25.27	22.75	25.17	22.86	25.07	22.97	24.97	23.08	34
35	26.01	23.42	25.91	23.53	25.80	23.65	25.70	23.76	35
36	26.75	24.09	26.65	24.21	26.54	24.32	26.44	24.44	36
37	27.50	24.76	27.39	24.88	27.28	25.00	27.17	25.12	37
38	28.24	25.43	28.13	25.55	28.02	25.67	27.90	25.79	38
39	28.98	26.10	28.87	26.22	28.75	26.35	28.64	26.47	39
40	29.73	26.77	29.61	26.89	29.49	27.02	29.37	27.15	40
41	30.47	27.43	30.35	27.57	30.23	27.70	30.11	27.83	41
42	31.21	28.10	31.09	28.24	30.97	28.37	30.84	28.51	42
43	31.96	28.77	31.83	28.91	31.70	29.05	31.58	29.19	43
44	32.70	29.44	32.57	29.58	32.44	29.73	32.31	29.87	44
45	33.44	30.11	33.31	30.26	33.18	30.40	33.04	30.55	45
46	34.18	30.78	34.05	30.93	33.91	31.08	33.78	31.22	46
47	34.93	31.45	34.79	31.60	34.65	31.75	34.51	31.90	47
48	35.67	32.12	35.53	32.27	35.39	32.43	35.25	32.58	48
49	36.41	32.79	36.27	32.95	36.13	33.10	35.98	33.26	49
50	37.16	33.46	37.01	33.62	36.86	33.78	36.72	33.94	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	48 Deg.		47¾ Deg.		47½ Deg.		47¼ Deg.		

Distance.	42 Deg.		42¼ Deg.		42½ Deg.		42¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	37.90	34.13	37.75	34.29	37.60	34.46	37.45	34.62	51
52	38.64	34.79	38.49	34.96	38.34	35.13	38.18	35.30	52
53	39.39	35.46	39.23	35.64	39.08	35.81	38.92	35.98	53
54	40.13	36.13	39.97	36.31	39.81	36.48	39.65	36.66	54
55	40.87	36.80	40.71	36.98	40.55	37.16	40.39	37.33	55
56	41.62	37.47	41.45	37.65	41.29	37.83	41.12	38.01	56
57	42.36	38.14	42.19	38.32	42.02	38.51	41.86	38.69	57
58	43.10	38.81	42.93	39.00	42.76	39.18	42.59	39.37	58
59	43.85	39.48	43.67	39.67	43.50	39.86	43.32	40.05	59
60	44.59	40.15	44.41	40.34	44.24	40.54	44.06	40.73	60
61	45.33	40.82	45.15	41.01	44.97	41.21	44.79	41.41	61
62	46.07	41.49	45.89	41.69	45.71	41.89	45.53	42.09	62
63	46.82	42.16	46.63	42.36	46.45	42.56	46.26	42.76	63
64	47.56	42.82	47.37	43.03	47.19	43.24	47.00	43.44	64
65	48.30	43.49	48.11	43.70	47.92	43.91	47.73	44.12	65
66	49.05	44.16	48.85	44.38	48.66	44.59	48.47	44.80	66
67	49.79	44.83	49.59	45.05	49.40	45.26	49.20	45.48	67
68	50.53	45.50	50.33	45.72	50.13	45.94	49.93	46.16	68
69	51.28	46.17	51.07	46.39	50.87	46.62	50.67	46.84	69
70	52.02	46.84	51.82	47.07	51.61	47.29	51.40	47.52	70
71	52.76	47.51	52.56	47.74	52.35	47.97	52.14	48.19	71
72	53.51	48.18	53.30	48.41	53.08	48.64	52.87	48.87	72
73	54.25	48.85	54.04	49.08	53.82	49.32	53.61	49.55	73
74	54.99	49.52	54.78	49.76	54.56	49.99	54.34	50.23	74
75	55.74	50.18	55.52	50.43	55.30	50.67	55.07	50.91	75
76	56.48	50.85	56.26	51.10	56.03	51.34	55.81	51.59	76
77	57.22	51.52	57.00	51.77	56.77	52.02	56.54	52.27	77
78	57.97	52.19	57.74	52.44	57.51	52.70	57.28	52.95	78
79	58.71	52.86	58.48	53.12	58.24	53.37	58.01	53.63	79
80	59.45	53.53	59.22	53.79	58.98	54.05	58.75	54.30	80
81	60.19	54.20	59.96	54.46	59.72	54.72	59.48	54.98	81
82	60.94	54.87	60.70	55.13	60.46	55.40	60.21	55.66	82
83	61.68	55.54	61.44	55.81	61.19	56.07	60.95	56.34	83
84	62.42	56.21	62.18	56.48	61.93	56.75	61.68	57.02	84
85	63.17	56.88	62.92	57.15	62.67	57.43	62.42	57.70	85
86	63.91	57.55	63.66	57.82	63.41	58.10	63.15	58.38	86
87	64.65	58.21	64.40	58.50	64.14	58.78	63.89	59.06	87
88	65.40	58.88	65.14	59.17	64.88	59.45	64.62	59.73	88
89	66.14	59.55	65.88	59.84	65.62	60.13	65.35	60.41	89
90	66.88	60.22	66.62	60.51	66.35	60.80	66.09	61.09	90
91	67.63	60.89	67.36	61.19	67.09	61.48	66.82	61.77	91
92	68.37	61.56	68.10	61.86	67.83	62.15	67.56	62.45	92
93	69.11	62.23	68.84	62.53	68.57	62.83	68.29	63.13	93
94	69.86	62.90	69.58	63.20	69.30	63.51	69.03	63.81	94
95	70.60	63.57	70.32	63.87	70.04	64.18	69.76	64.49	95
96	71.34	64.24	71.06	64.55	70.78	64.86	70.49	65.16	96
97	72.08	64.91	71.80	65.22	71.52	65.53	71.23	65.84	97
98	72.83	65.57	72.54	65.89	72.25	66.21	71.96	66.52	98
99	73.57	66.24	73.28	66.56	72.99	66.88	72.70	67.20	99
100	74.31	66.91	74.02	67.24	73.73	67.56	73.43	67.88	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	48 Deg.		47¾ Deg.		47½ Deg.		47¼ Deg.		

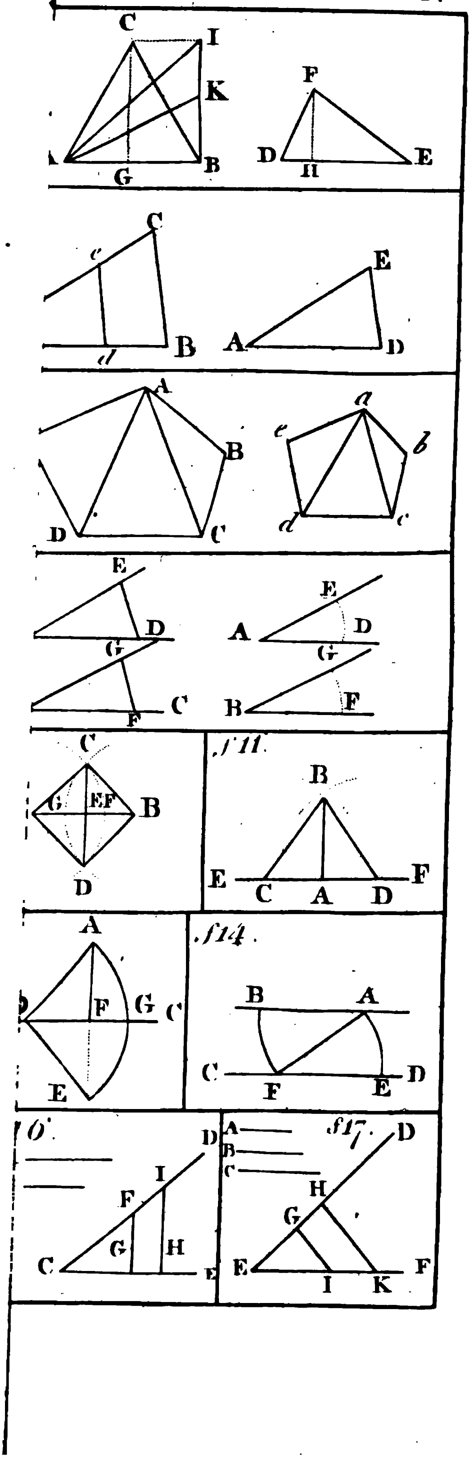
Distance.	43 Deg.		43¼ Deg.		43½ Deg.		43¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.73	0.68	0.73	0.69	0.73	0.69	0.72	0.69	1
2	1.46	1.36	1.46	1.37	1.45	1.38	1.44	1.38	2
3	2.19	2.05	2.19	2.06	2.18	2.07	2.17	2.07	3
4	2.93	2.73	2.91	2.74	2.90	2.75	2.89	2.77	4
5	3.66	3.41	3.64	3.43	3.63	3.44	3.61	3.46	5
6	4.39	4.09	4.37	4.11	4.35	4.13	4.33	4.15	6
7	5.12	4.77	5.10	4.80	5.08	4.82	5.06	4.84	7
8	5.85	5.46	5.83	5.48	5.80	5.51	5.78	5.53	8
9	6.58	6.14	6.56	6.17	6.53	6.20	6.50	6.22	9
10	7.31	6.82	7.28	6.85	7.25	6.88	7.22	6 92	10
11	8.04	7.50	8.01	7.54	7.98	7.57	7.95	7.61	11
12	8.78	8.18	8.74	8.22	8.70	8.26	8.67	8.30	12
13	9.51	8.87	9.47	8.91	9.43	8.95	9.39	8.99	13
14	10.24	9.55	10.20	9.59	10.16	9.64	10.11	9.68	14
15	10.97	10.23	10.93	10.28	10.88	10.33	10.84	10.37	15
16	11.70	10.91	11.65	10.96	11.61	11.01	11.56	11.06	16
17	12.43	11.59	12.38	11.65	12.33	11.70	12.28	11.76	17
18	13.16	12.28	13.11	12.33	13.06	12.39	13.00	12.45	18
19	13.90	12.96	13.84	13.02	13.78	13.08	13.72	13.14	19
20	14.63	13.64	14.57	13.70	14.51	13.77	14.45	13.83	20
21	15.36	14.32	15.30	14.39	15.23	14.46	15.17	14.52	21
22	16.09	15.00	16.02	15.07	15.96	15.14	15.89	15.21	22
23	16.82	15.69	16.75	15.76	16.68	15.83	16.61	15.90	23
24	17.55	16.37	17.48	16.44	17.41	16.52	17.34	16.60	24
25	18.28	17.05	18.21	17.13	18.13	17.21	18.06	17.29	25
26	19.02	17.73	18.94	17.81	18.86	17.90	18.78	17.98	26
27	19.75	18.41	19.67	18 50	19.59	18.59	19.50	18.67	27
28	20.48	19.10	20.39	19.19	20.31	19.27	20.23	19.36	28
29	21.21	19.78	21.12	19.87	21.04	19.96	20.95	20.05	29
30	21.94	20.46	21.85	20.56	21.76	20.65	21.67	20.75	30
31	22.67	21.14	22.58	21.24	22.49	21.34	22.39	21.44	31
32	23.40	21.82	23.31	21.93	23.21	22.03	23.12	22.13	32
33	24.13	22.51	24.04	22.61	23.94	22.72	23.84	22.82	33
34	24.87	23.19	24.76	23.30	24.66	23.40	24.56	23.51	34
35	25.60	23.87	25.49	23.98	25.39	24.09	25.28	24.20	35
36	26.33	24.55	26.22	24.67	26.11	24.78	26.01	24.89	36
37	27.06	25.23	26.95	25.35	26.84	25.47	26.73	25.59	37
38	27.79	25.92	27.68	26.04	27.56	26.16	27.45	26.28	38
39	28.52	26.60	28.41	26.72	28.29	26.85	28.17	26.97	39
40	29.25	27.28	29.13	27.41	29.01	27.53	28.89	27.66	40
41	29.99	27.96	29.86	28.09	29.74	28.22	29.62	28.35	41
42	30.72	28.64	30.59	28.78	30.47	28.91	30.34	29.04	42
43	31.45	29.33	31.32	29.46	31.19	29.60	31.06	29.74	43
44	32.18	30.01	32.05	30.15	31.92	30.29	31.78	30.43	44
45	32.91	30.69	32.78	30.83	32.64	30.98	32.51	31.12	45
46	33.64	31.37	33.51	31.52	33.37	31.66	33.23	31.81	46
47	34.37	32.05	34.23	32.20	34.09	32.35	33.95	32.50	47
48	35.10	32.74	34.96	32.89	34.82	33.04	34.67	33.19	48
49	35.84	33.42	35.69	33.57	35.54	33.73	35.40	33.88	49
50	36.57	34.10	36.42	34.26	36.27	34.42	36.12	34.58	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	47 Deg.		46¾ Deg.		46½ Deg.		46¼ Deg.		

Distance.	43 Deg.		43¼ Deg.		43½ Deg.		43¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	37.30	34.78	37.15	34.94	36.99	35.11	36.84	35.27	51
52	38.03	35.46	37.88	35.63	37.72	35.79	37.56	35.96	52
53	38.76	36.15	38.60	36.31	38.44	36.48	38.29	36.65	53
54	39.49	36.83	39.33	37.00	39.17	37.17	39.01	37.34	54
55	40.22	37.51	40.06	37.69	39.90	37.86	39.73	38.03	55
56	40.96	38.19	40.79	38.37	40.62	38.55	40.45	38.72	56
57	41.69	38.87	41.52	39.06	41.35	39.24	41.17	39.42	57
58	42.42	39.56	42.25	39.74	42.07	39.92	41.90	40.11	58
59	43.15	40.24	42.97	40.43	42.80	40.61	42.62	40.80	59
60	43.88	40.92	43.70	41.11	43.52	41.30	43.34	41.49	60
61	44.61	41.60	44.43	41.80	44.25	41.99	44.06	42.18	61
62	45.34	42.28	45.16	42.48	44.97	42.68	44.79	42.87	62
63	46.08	42.97	45.89	43.17	45.70	43.37	45.51	43.57	63
64	46.81	43.65	46.62	43.85	46.42	44.05	46.23	44.26	64
65	47.54	44.33	47.34	44.54	47.15	44.74	46.95	44.95	65
66	48.27	45.01	48.07	45.22	47.87	45.43	47.68	45.64	66
67	49.00	45.69	48.80	45.91	48.60	46.12	48.40	46.33	67
68	49.73	46.38	49.53	46.59	49.33	46.81	49.12	47.02	68
69	50.46	47.06	50.26	47.28	50.05	47.50	49.84	47.71	69
70	51.19	47.74	50.99	47.96	50.78	48.18	50.57	48.41	70
71	51.93	48.42	51.71	48.65	51.50	48.87	51.29	49.10	71
72	52.66	49.10	52.44	49.33	52.23	49.56	52.01	49.79	72
73	53.39	49.79	53.17	50.02	52.95	50.25	52.73	50.48	73
74	54.12	50.47	53.90	50.70	53.68	50.94	53.45	51.17	74
75	54.85	51.15	54.63	51.39	54.40	51.63	54.18	51.86	75
76	55.58	51.83	55.36	52.07	55.13	52.31	54.90	52.55	76
77	56.31	52.51	56.08	52.76	55.85	53.00	55.62	53.25	77
78	57.05	53.20	56.81	53.44	56.58	53.69	56.34	53.94	78
79	57.78	53.88	57.54	54.13	57.30	54.38	57.07	54.63	79
80	58.51	54.56	58.27	54.81	58.03	55.07	57.79	55.32	80
81	59.24	55.24	59.00	55.50	58.76	55.76	58.51	56.01	81
82	59.97	55.92	59.73	56.18	59.48	56.45	59.23	56.70	82
83	60.70	56.61	60.45	56.87	60.21	57.13	59.96	57.40	83
84	61.43	57.29	61.18	57.56	60.93	57.82	60.68	58.09	84
85	62.17	57.97	61.91	58.24	61.66	58.51	61.40	58.78	85
86	62.90	58.65	62.64	58.93	62.38	59.20	62.12	59.47	86
87	63.63	59.33	63.37	59.61	63.11	59.89	62.85	60.16	87
88	64.36	60.02	64.10	60.30	63.83	60.58	63.57	60.85	88
89	65.09	60.70	64.82	60.98	64.56	61.26	64.29	61.54	89
90	65.82	61.38	65.55	61.67	65.28	61.95	65.01	62.24	90
91	66.55	62.06	66.28	62.35	66.01	62.64	65.74	62.93	91
92	67.28	62.74	67.01	63.04	66.73	63.33	66.46	63.62	92
93	68.02	63.43	67.74	63.72	67.46	64.02	67.18	64.31	93
94	68.75	64.11	68.47	64.41	68.19	64.71	67.90	65.00	94
95	69.48	64.79	69.20	65.09	68.91	65.39	68.62	65.69	95
96	70.21	65.47	69.92	65.78	69.64	66.08	69.35	66.39	96
97	70.94	66.15	70.65	66.46	70.36	66.77	70.07	67.08	97
98	71.67	66.84	71.37	67.15	71.09	67.46	70.79	67.77	98
99	72.40	67.52	72.11	67.83	71.81	68.15	71.51	68.46	99
100	73.14	68.20	72.84	68.52	72.54	68.84	72.24	69.15	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	47 Deg.		46¾ Deg.		46½ Deg.		46¼ Deg.		

Distance	44 Deg. Lat.	44 Deg. Dep.	44¼ Deg. Lat.	44¼ Deg. Dep.	44½ Deg. Lat.	44½ Deg. Dep.	44¾ Deg. Lat.	44¾ Deg. Dep.	45 Deg. Lat.	45 Deg. Dep.
1	0.72	0.69	0.72	0.70	0.71	0.70	0.71	0.71	0.71	0.71
2	1.44	1.39	1.43	1.40	1.43	1.40	1.42	1.41	1.41	1.41
3	2.16	2.08	2.15	2.09	2.14	2.10	2.13	2.11	2.12	2.12
4	2.88	2.78	2.87	2.79	2.85	2.80	2.84	2.82	2.83	2.83
5	3.60	3.47	3.58	3.49	3.57	3.50	3.55	3.52	3.54	3.54
6	4.32	4.17	4.30	4.19	4.28	4.21	4.26	4.22	4.24	4.24
7	5.04	4.86	5.01	4.88	4.99	4.91	4.97	4.93	4.95	4.95
8	5.75	5.56	5.73	5.58	5.71	5.61	5.68	5.63	5.66	5.66
9	6.47	6.25	6.45	6.28	6.42	6.31	6.39	6.34	6.36	6.36
10	7.19	6.95	7.16	6.98	7.13	7.01	7.10	7.04	7.07	7.07
11	7.91	7.64	7.88	7.68	7.85	7.71	7.81	7.74	7.78	7.78
12	8.63	8.34	8.60	8.37	8.56	8.41	8.52	8.45	8.49	8.49
13	9.35	9.03	9.31	9.07	9.27	9.11	9.23	9.15	9.19	9.19
14	10.07	9.73	10.03	9.77	9.99	9.81	9.94	9.86	9.90	9.90
15	10.79	10.42	10.74	10.47	10.70	10.51	10.65	10.56	10.61	10.61
16	11.51	11.11	11.46	11.16	11.41	11.21	11.36	11.26	11.31	11.31
17	12.23	11.81	12.18	11.86	12.13	11.92	12.07	11.97	12.02	12.02
18	12.95	12.50	12.89	12.56	12.84	12.62	12.78	12.67	12.73	12.73
19	13.67	13.20	13.61	13.26	13.55	13.32	13.49	13.38	13.43	13.43
20	14.39	13.89	14.33	13.96	14.26	14.02	14.20	14.08	14.14	14.14
21	15.11	14.59	15.04	14.65	14.98	14.72	14.91	14.78	14.85	14.85
22	15.83	15.28	15.76	15.35	15.69	15.42	15.62	15.49	15.56	15.56
23	16.54	15.98	16.47	16.05	16.40	16.12	16.33	16.19	16.26	16.26
24	17.26	16.67	17.19	16.75	17.12	16.82	17.04	16.99	16.97	16.97
25	17.98	17.37	17.91	17.44	17.83	17.52	17.75	17.60	17.68	17.68
26	18.70	18.06	18.62	18.11	18.54	18.22	18.46	18.30	18.38	18.38
27	19.42	18.76	19.34	18.84	19.26	18.92	19.17	19.01	19.09	19.09
28	20.14	19.45	20.06	19.54	19.97	19.63	19.89	19.71	19.80	19.80
29	20.86	20.15	20.77	20.24	20.68	20.33	20.60	20.42	20.51	20.51
30	21.58	20.84	21.49	20.93	21.40	21.03	21.31	21.12	21.21	21.21
31	22.30	21.53	22.21	21.63	22.11	21.73	22.02	21.82	21.92	21.92
32	23.02	22.23	22.92	22.33	22.82	22.43	22.73	22.53	22.63	22.63
33	23.74	22.92	23.64	23.03	23.54	23.13	23.44	23.23	23.33	23.33
34	24.46	23.62	24.35	23.72	24.25	23.83	24.15	23.94	24.04	24.04
35	25.18	24.31	25.07	24.42	24.96	24.53	24.86	24.64	24.75	24.75
36	25.90	25.01	25.79	25.12	25.68	25.23	25.57	25.34	25.46	25.46
37	26.62	25.70	26.50	25.82	26.39	25.93	26.28	26.05	26.16	26.16
38	27.33	26.40	27.22	26.52	27.10	26.63	26.99	26.75	26.87	26.87
39	28.05	27.09	27.94	27.21	27.82	27.34	27.70	27.46	27.58	27.58
40	28.77	27.79	28.65	27.91	28.53	28.04	28.41	28.16	28.28	28.28
41	29.49	28.48	29.37	28.61	29.24	28.74	29.12	28.86	28.99	28.99
42	30.21	29.18	30.08	29.31	29.96	29.44	29.83	29.57	29.70	29.70
43	30.93	29.87	30.80	30.00	30.67	30.14	30.54	30.27	30.41	30.41
44	31.65	30.56	31.52	30.70	31.38	30.84	31.25	30.98	31.11	31.11
45	32.37	31.26	32.23	31.40	32.10	31.54	31.96	31.68	31.82	31.82
46	33.09	31.95	32.95	32.10	32.81	32.24	32.67	32.38	32.53	32.53
47	33.81	32.65	33.67	32.80	33.52	32.94	33.38	33.09	33.23	33.23
48	34.53	33.34	34.38	33.49	34.24	33.64	34.09	33.79	33.94	33.94
49	35.25	34.04	35.10	34.19	34.95	34.34	34.80	24.50	34.65	34.65
50	35.97	34.73	35.82	34.89	35.66	35.05	35.51	35.20	35.36	35.36
Distance	46 Deg. Dep.	46 Deg. Lat.	45¾ Deg. Dep.	45¾ Deg. Lat.	45½ Deg. Dep.	45½ Deg. Lat.	45¼ Deg. Dep.	45¼ Deg. Lat.	45 Deg. Dep.	45 Deg. Lat.

Distance.	44 Deg.		44¼ Deg.		44½ Deg.		44¾ Deg.		45 Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	36.69	35.43	36.53	35.59	36.38	35.75	36.22	35.90	36.06	36.06	51
52	37.41	36.12	37.25	36.29	37.09	36.45	36.93	36.61	36.77	36.77	52
53	38.12	36.82	37.96	36.98	37.80	37.15	37.64	37.31	37.48	37.48	53
54	38.84	37.51	38.68	37.68	38.52	37.85	38.35	38.02	38.18	38.18	54
55	39.56	38.21	39.40	38.38	39.23	38.55	39.06	38.72	38.89	38.89	55
56	40.28	38.90	40.11	39.08	39.94	39.25	39.77	39.42	39.60	39.60	56
57	41.00	39.60	40.83	39.77	40.66	39.95	40.48	40.13	40.31	40.31	57
58	41.72	40.29	41.55	40.47	41.37	40.65	41.19	40.83	41.01	41.01	58
59	42.44	40.98	42.26	41.17	42.08	41.35	41.90	41.54	41.72	41.72	59
60	43.16	41.68	42.98	41.87	42.79	42.05	42.61	42.24	42.43	42.43	60
61	43.88	42.37	43.69	42.57	43 51	42.76	43.32	42.94	43.13	43.13	61
62	44.60	43.07	44.41	43.26	44.22	43.46	44.03	43.65	43.84	43.84	62
63	45.32	43.76	45.13	43.96	44.93	44.16	44.74	44.35	44.55	44.55	63
64	46.04	44.46	45.84	44.66	45.65	44.86	45.45	45.06	45.25	45.25	64
65	46.76	45.15	46.56	45.36	46.36	45.56	46.16	45.76	45.96	45.96	65
66	47.48	45.85	47.28	46.05	47.07	46.26	46.87	46.46	46.67	46.67	66
67	48.20	46.54	47.99	46.75	47.79	46.96	47.58	47.17	47.38	47.38	67
68	48.92	47.24	48.71	47.45	48.50	47.66	48.29	47.87	48.08	48.08	68
69	49.63	47.93	49.42	48.15	49.21	48.36	49.00	48.58	48.79	48.79	69
70	50.35	48.63	50.14	48.85	49.93	49.06	49.71	49.28	49.50	49.50	70
71	51.07	49.32	50.86	49.54	50.64	49.76	50.42	49.98	50.20	50.20	71
72	51.79	50.02	51.57	50.24	51.35	50.47	51.13	50.69	50.91	50.91	72
73	52.51	50.71	52.29	50.94	52.07	51.17	51.84	51.39	51.62	51.62	73
74	53.23	51.40	53.01	51.64	52.78	51.87	52.55	52.10	52.33	52.33	74
75	53.95	52.10	53.72	52.33	53.49	52.57	53.26	52.80	53.03	53.03	75
76	54.67	52.79	54.44	53.03	54.21	53.27	53.97	53.51	53.74	53.74	76
77	55.39	53.49	55.16	53.73	54.92	53.97	54.68	54.21	54.45	54.45	77
78	56.11	54.18	55.87	54.43	55.63	54.67	55.39	54.91	55.15	55.15	78
79	56.83	54.88	56.59	55.13	56.35	55.37	56.10	55.62	55.86	55.86	79
80	57.55	55.57	57.30	55.82	57.06	56.07	56.81	56.32	56.57	56.57	80
81	58.27	56.27	58.02	56.52	57.77	56.77	57.52	57.03	57.28	57.28	81
82	58.99	56.96	58.74	57.22	58.49	57.47	58.24	57.73	57.98	57.98	82
83	59.71	57.66	59.45	57.92	59.20	58.18	58.95	58.43	58.69	58.69	83
84	60.42	58.35	60.17	58.61	59.91	58.88	59.66	59.14	59.40	59.40	84
85	61.14	59.05	60.89	59.31	60.63	59.58	60.37	59.84	60.10	60.10	85
86	61.86	59.74	61.60	60.01	61.34	60.28	61.08	60.55	60.81	60.81	86
87	62.58	60.44	62.32	60.71	62.05	60.98	61.79	61.25	61.52	61.52	87
88	63.30	61.13	63.03	61.41	62.77	61.68	62.50	61.95	62.23	62.23	88
89	64.02	61.82	63.75	62.10	63.48	62.38	63.21	62.66	62.93	62.93	89
90	64.74	62.52	64.47	62.80	64.19	63.08	63.92	63.36	63.64	63.64	90
91	65.46	63.21	65.18	63.50	64.91	63.78	64.63	64.07	64.35	64.85	91
92	66.18	63.91	65.90	64.20	65.62	64.48	65.34	64.77	65.05	65.05	92
93	66.90	64.60	66.62	64.89	66.33	65.18	66.05	65.47	65.76	65.76	93
94	67.62	65.30	67.33	65.59	67.05	65.89	66.76	66.18	66.47	66.47	94
95	68.34	65.99	68.05	66.29	67.76	66.59	67.47	66.88	67.18	67.18	95
96	69.06	66.69	68.76	66.99	68.47	67.29	68.18	67.59	67.88	67.88	96
97	69.78	67.38	69.48	67.69	69.19	67.99	68.89	68.29	68.59	68.59	97
98	70.50	68.08	70.20	68.38	69.90	68.69	69.60	68.99	69.30	69.30	98
99	71.21	68.77	70.91	69.08	70.61	69.39	70.31	69.70	70.00	70.00	99
100	71.93	69.47	71.63	69.78	71.33	70.09	71.02	70.40	70.71	70.71	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	46 Deg.		45¾ Deg.		45½ Deg.		45¼ Deg.		45 Deg.		

II.



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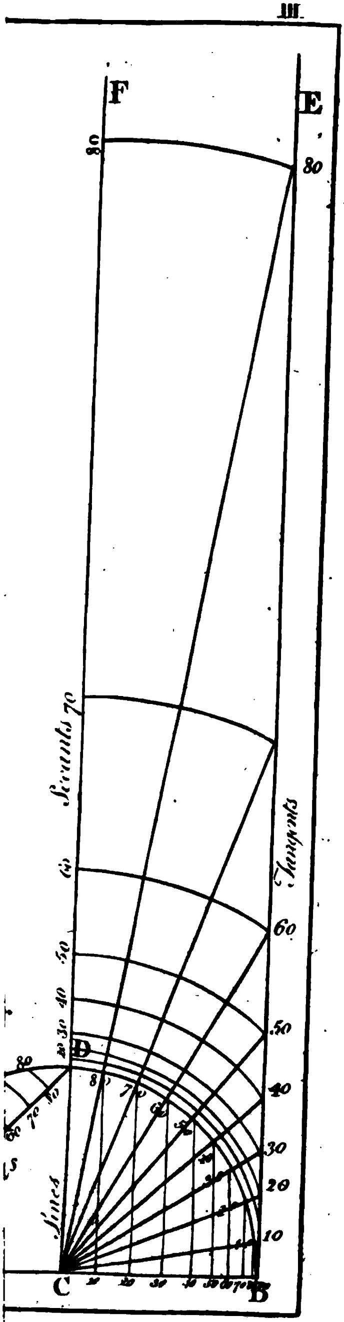
III.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Secants 70
Tangents
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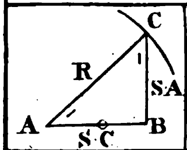
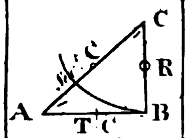
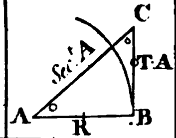
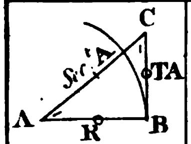
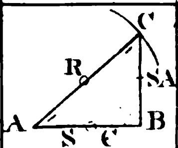
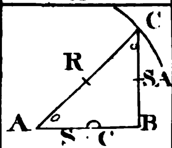
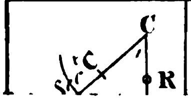
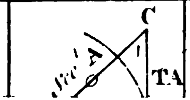
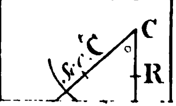
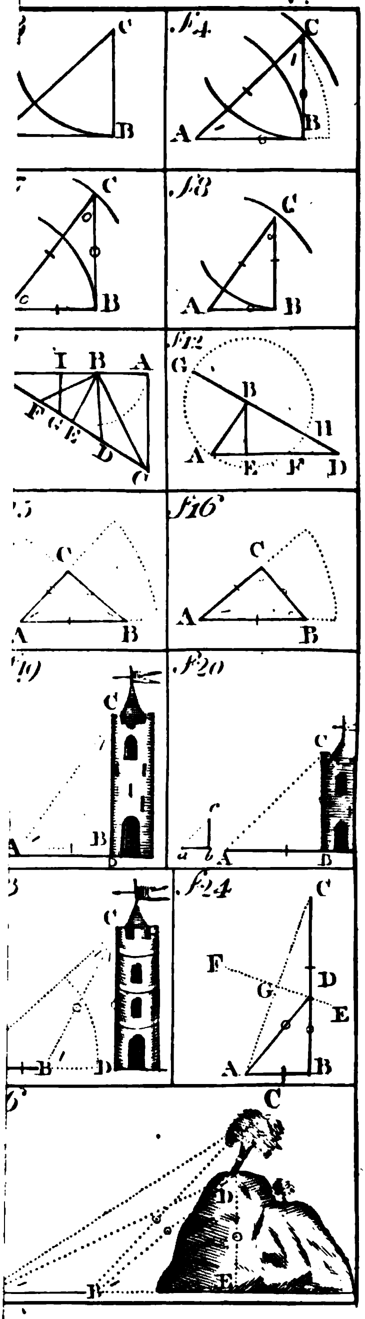
Plate 4. IV.

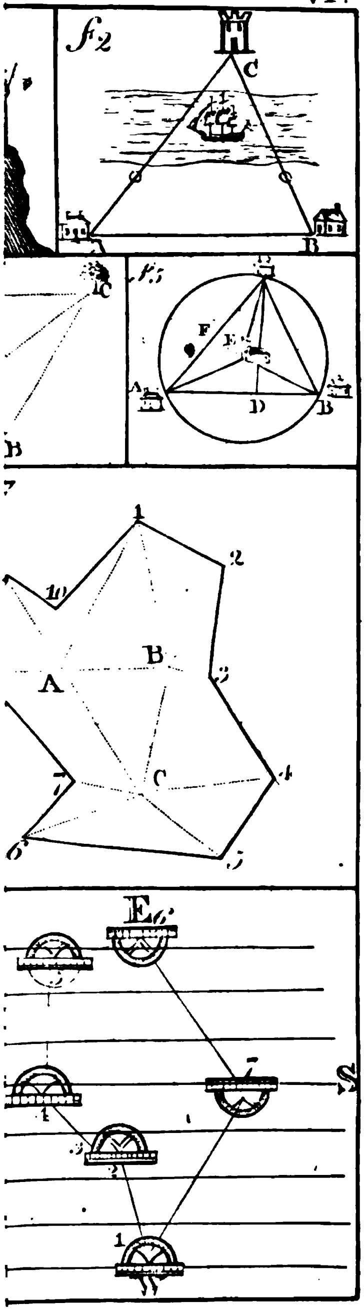
The Proportions for the Solution of 6 Cases of Right Angled Plain Triangles

	*Case 1.* R : AC :: SA : BC R : AC :: SC : AB		TC : AB :: R : BC TC : AB :: Sec.'C : AC		AB : R :: AC : Sec.'A R : AB :: TA : BC
	Sec.'A : AC :: R : AB Sec.'A : AC :: TA : BC		*Case 3.* SA : BC :: R : AC SA : BC :: SC : AB		*Case 5.* AC : R :: BC : SA R : AC :: SC : AB
	Sec.'C : AC :: R : BC [illegible]		TA : BC :: R : AB [illegible]		BC : R :: AC : Sec.'C R : BC :: TC : AB

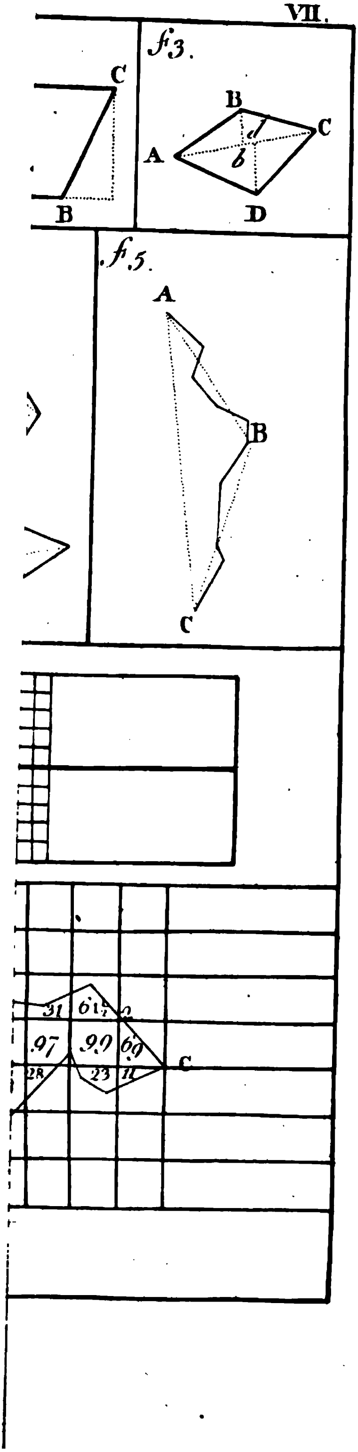
V.



VI.



VII.



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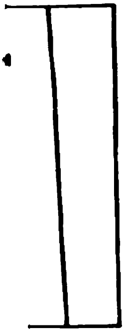
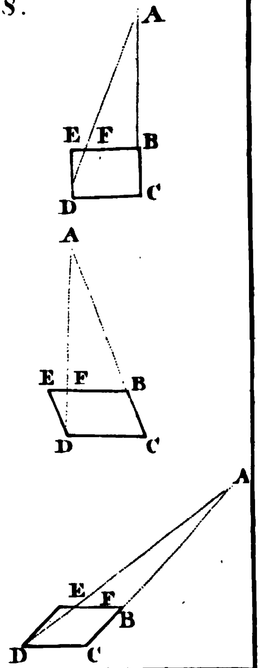


f.3.

f.8.



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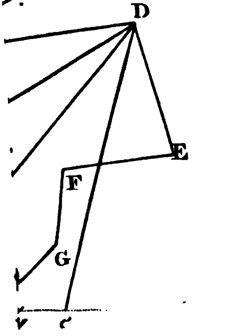

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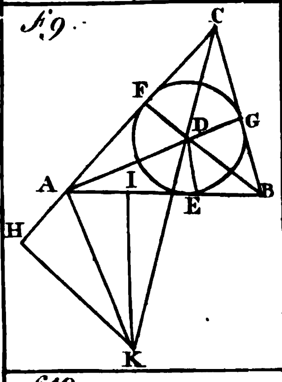

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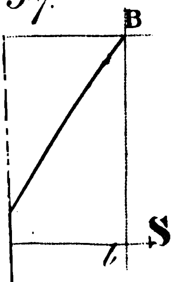

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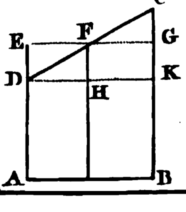

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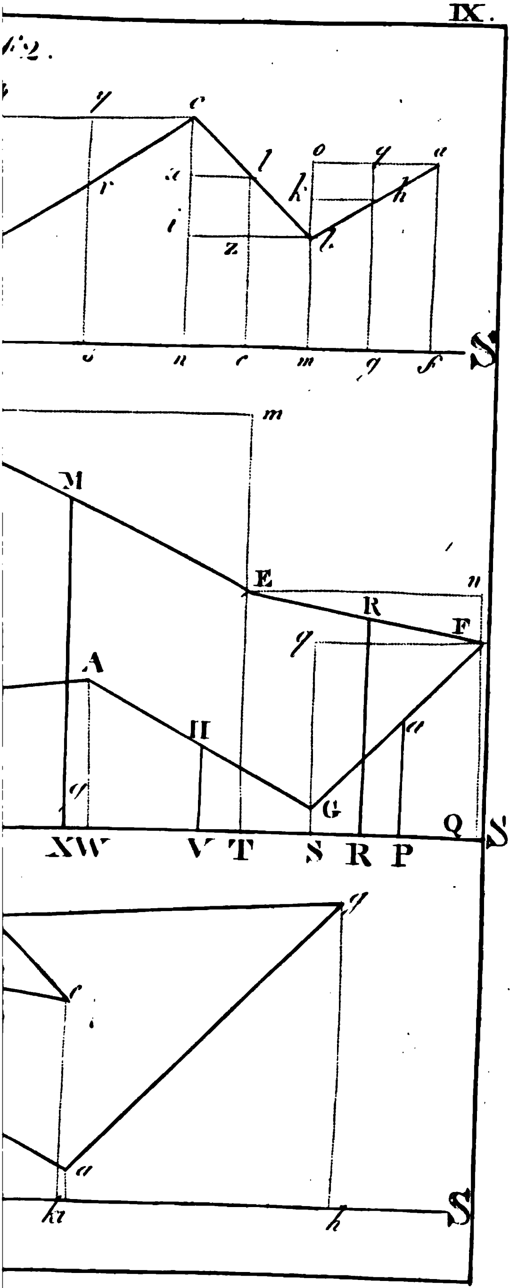

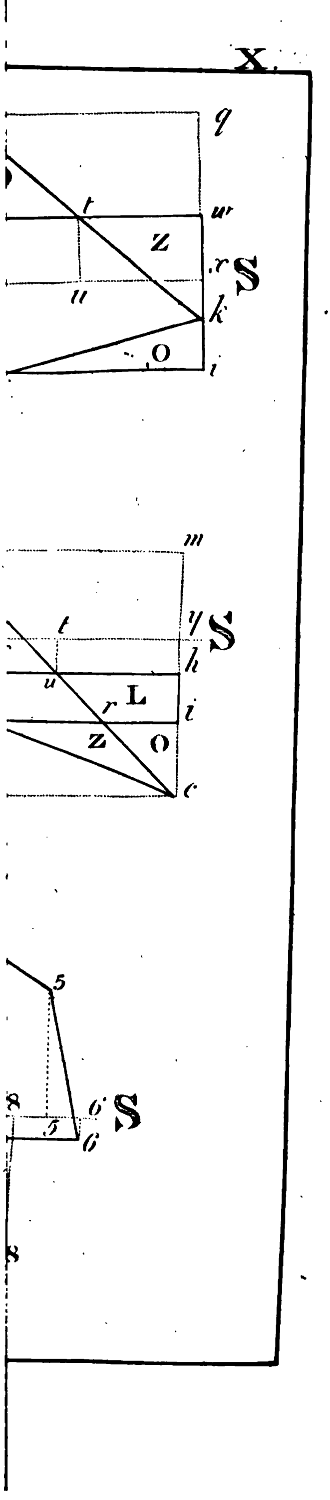
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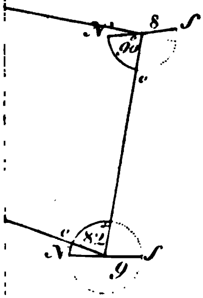
XI.

f. 1.



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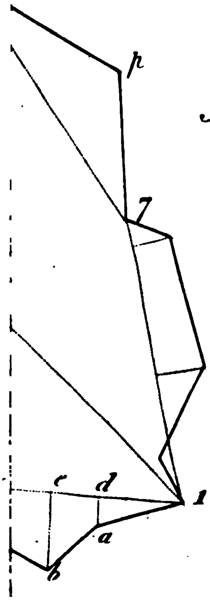
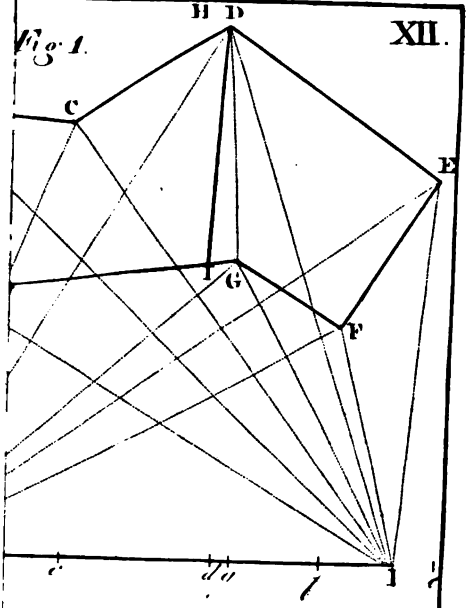


XII.

Fig 1.



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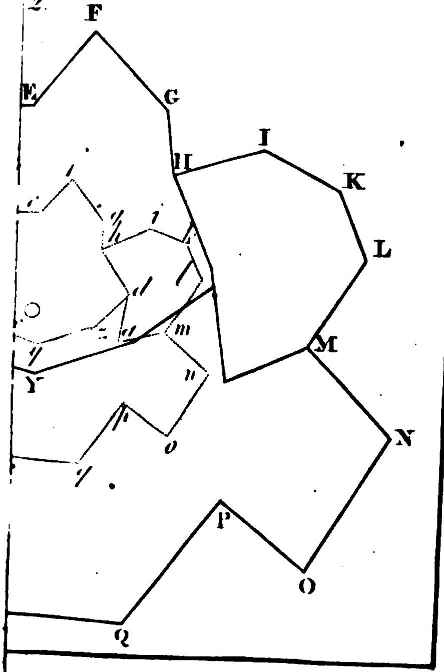

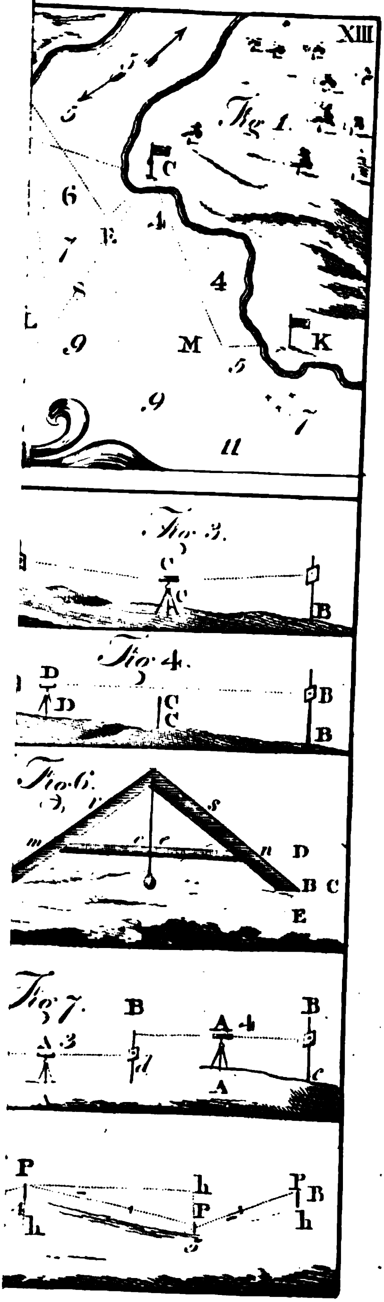
XIII
Fig. 1.
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Fig. 3.
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Fig. 4.
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Fig. 6.
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Fig. 7.
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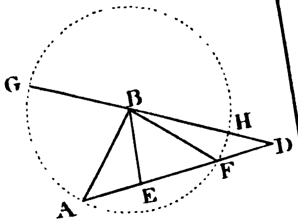
F. 3.



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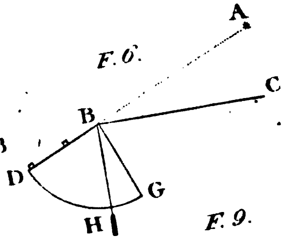

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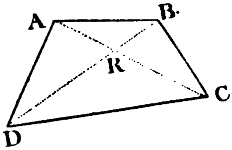

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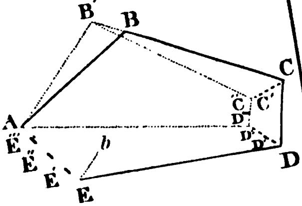

F. 13.